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BAC Report No. 8654-953005

FINAL REPORT APPENDIX

NONDESTRUCTIVE TESTS OF REGENERATIVE CHAMBERS

By

G. A. MALONE
L. VECCHIES
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Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JUNE 1974

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16. Abstract

The objective of this program was to define the capabilities and limitations of nondestructive evaluation methods to detect and locate bond deficiencies in regeneratively cooled thrust chambers for rocket engines. Nondestructive evaluation methods used were those of demonstrated capability from previous work under Contract NAS 3-14376 (NASA Report CR-120980).

Under this contract, flat test panels and a cylinder were produced to simulate regeneratively cooled thrust chamber walls. Planned defects with various bond integrities were produced in the panels to evaluate the sensitivity, accuracy, and limitations of nondestructive methods to define and locate bond anomalies. Holography, accustic emission, and ultrasonic "C" scan were found to yield sufficient data to discern bond quality when used in combination and in selected sequences. Bonding techniques included electroforming and brazing. Materials of construction included electroformed nickel bonded to Nickel 200 and OFHC copper, electroformed copper bonded to OFHC copper, and 300 series stainless steel brazed to OFHC copper. Variations in outer wall strength, wall thickness, and defect size were evaluated for nondestructive test response.

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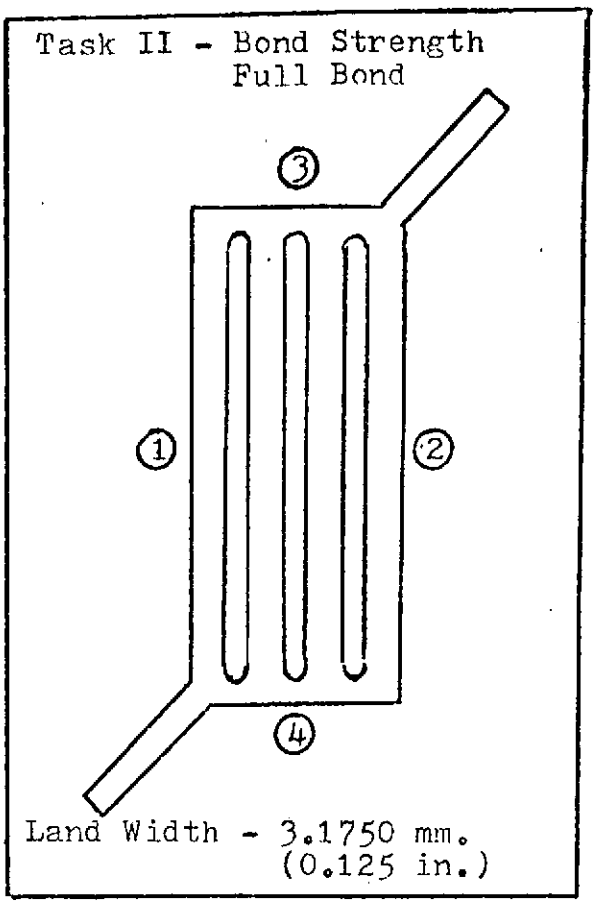
CONTENTS

SECTION C - TASK IV NDE PANELS FOR EQUIPMENT LIMITATION STUDY

ELECTROFORMED PANEL NO. N-08



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: ±0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.3500	0.2500
②	6.3525	0.2501
③	6.2433	0.2458
④	6.3500	0.2500

COVERPLATE

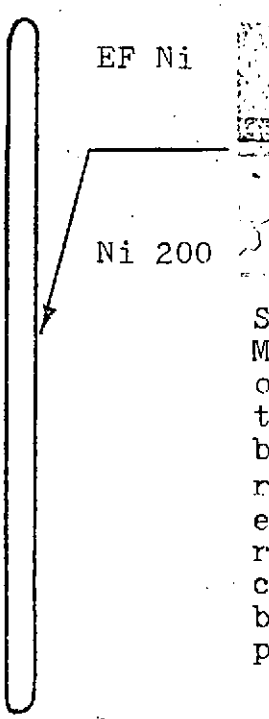
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4834	0.0584
②	1.4453	0.0569
③	1.5748	0.0620
④	1.4122	0.0556

PRESSURE REQUIRED TO FAIL BOND:

Bond did not fail at a pressure of 6.90×10^7 N/m^2 (10,000 psi)

CENTER LAND DEFECT

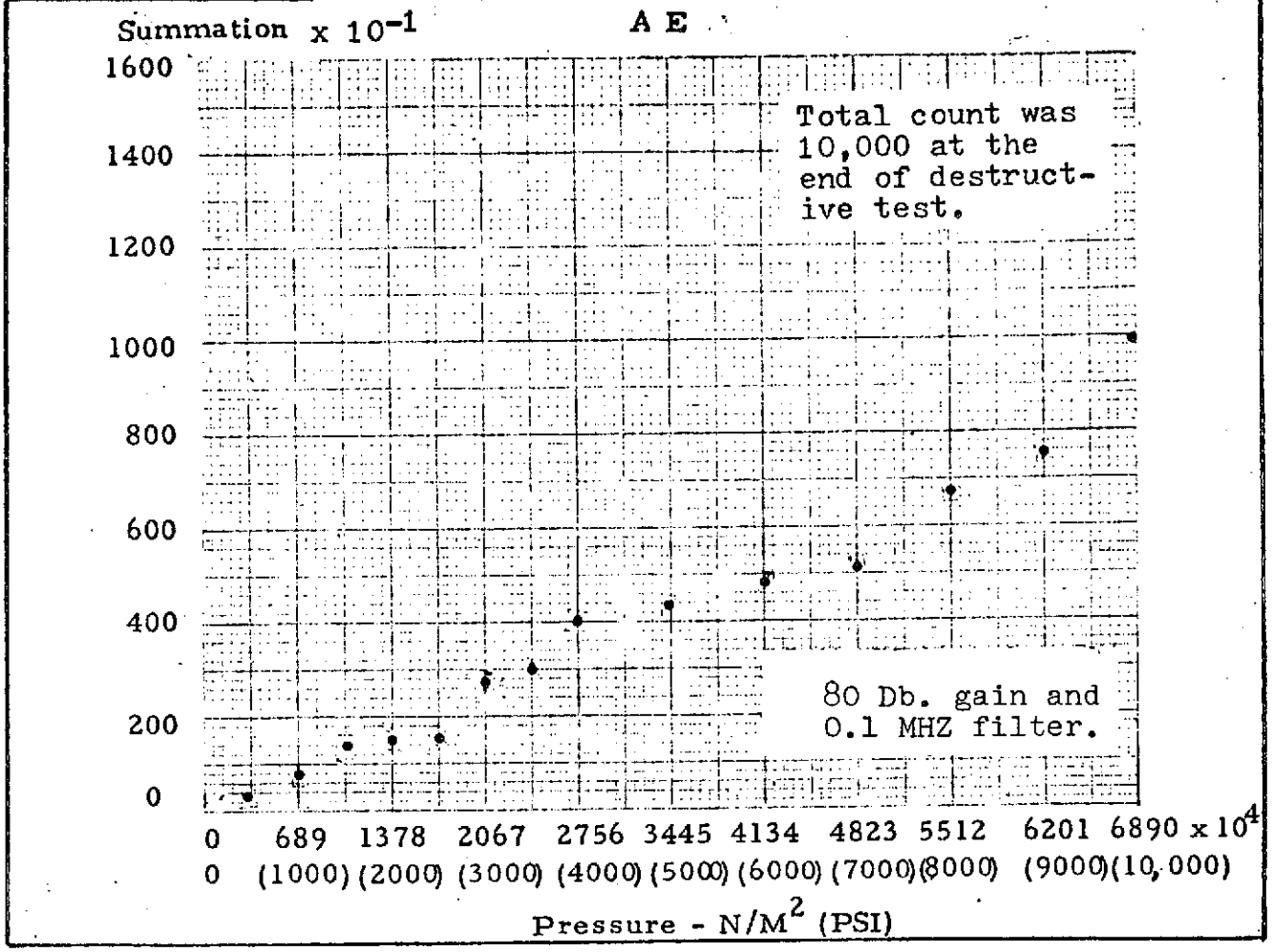


METALLOGRAPHIC ANALYSIS:

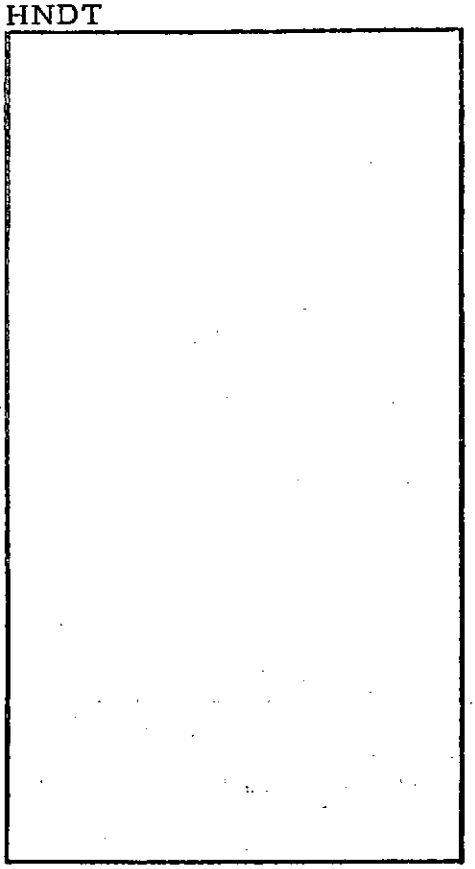
Section showing unfailed full bond. Magnification 50X. Note the presence of two intentional plating stops in the coverplate material next to the bondline. The bonding rib edge at the right hand side of the picture shows evidence of "edge bonding" which often results in high acoustic emission counts. This can falsely idicate weak bond when a full bond is actually present.

FIGURE A-1

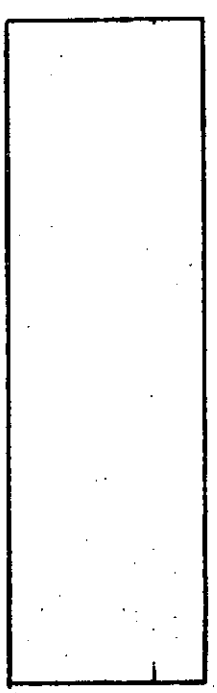
Panel No. N-08



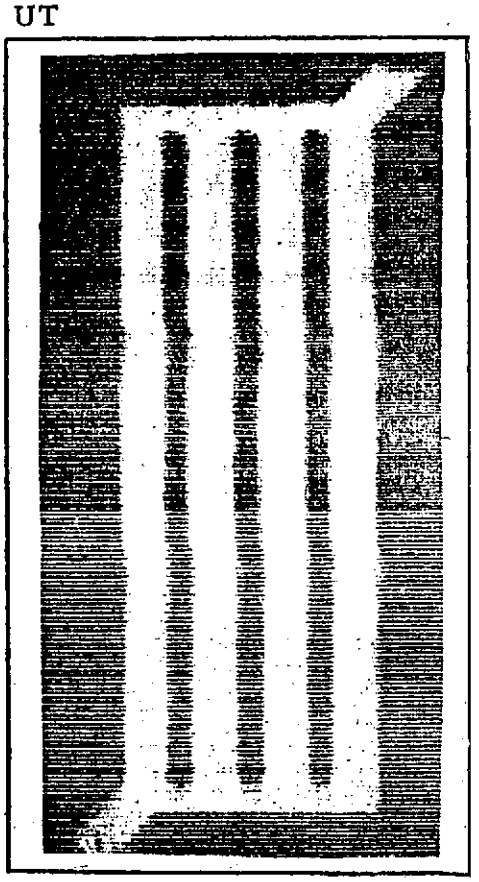
HNDT



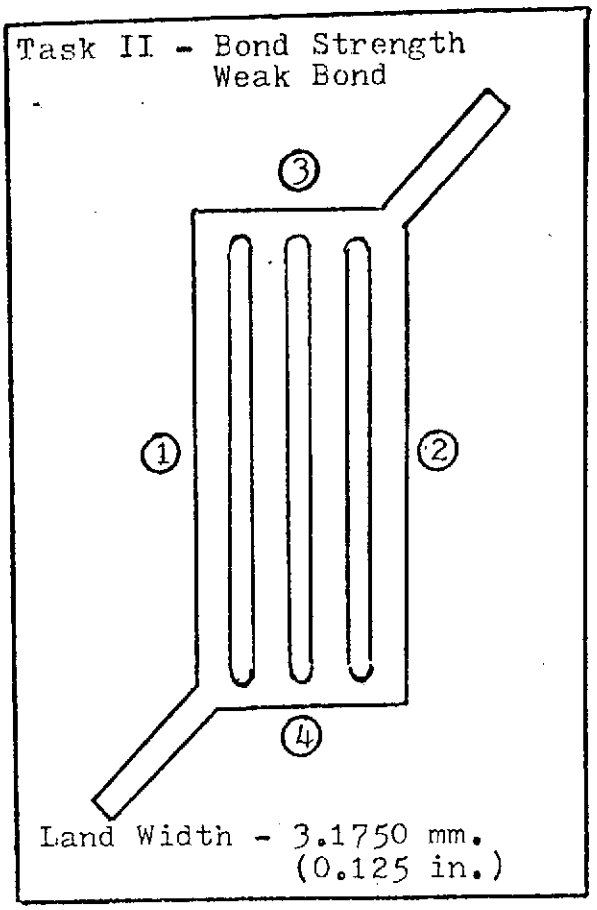
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-07



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.007 in. (0.1778 mm.)

THICKNESS:	MM.	INCHES
①	6.2433	0.2458
②	6.2433	0.2458
③	6.2306	0.2453
④	6.2281	0.2452

COVERPLATE

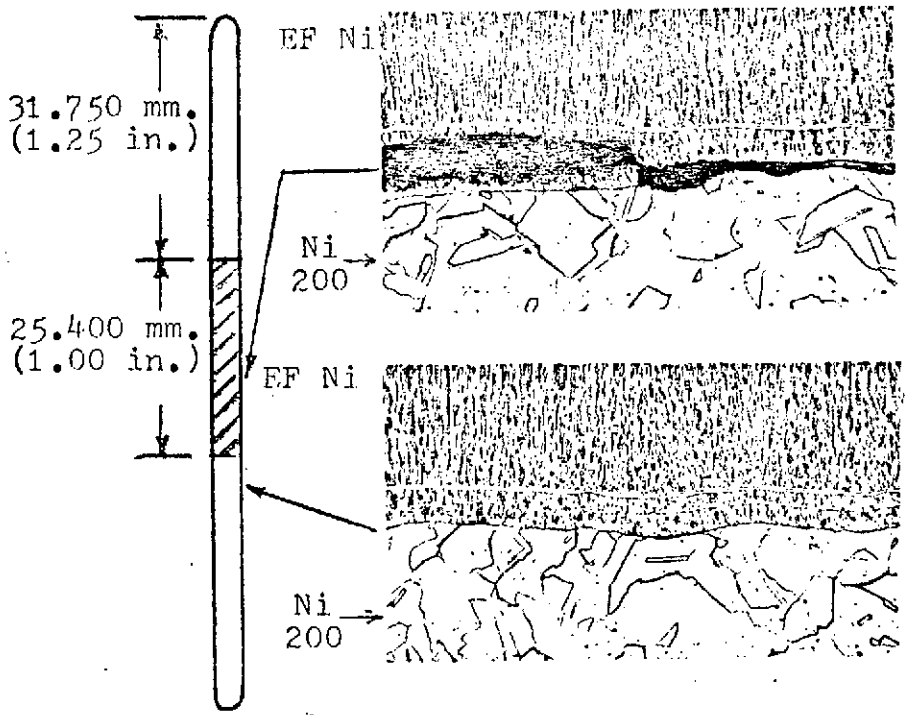
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.3614	0.0536
②	1.3335	0.0525
③	1.3462	0.0530
④	1.3614	0.0536

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 4.69×10^7 N/m^2 (6,800 psi)

CENTER LAND DEFECT



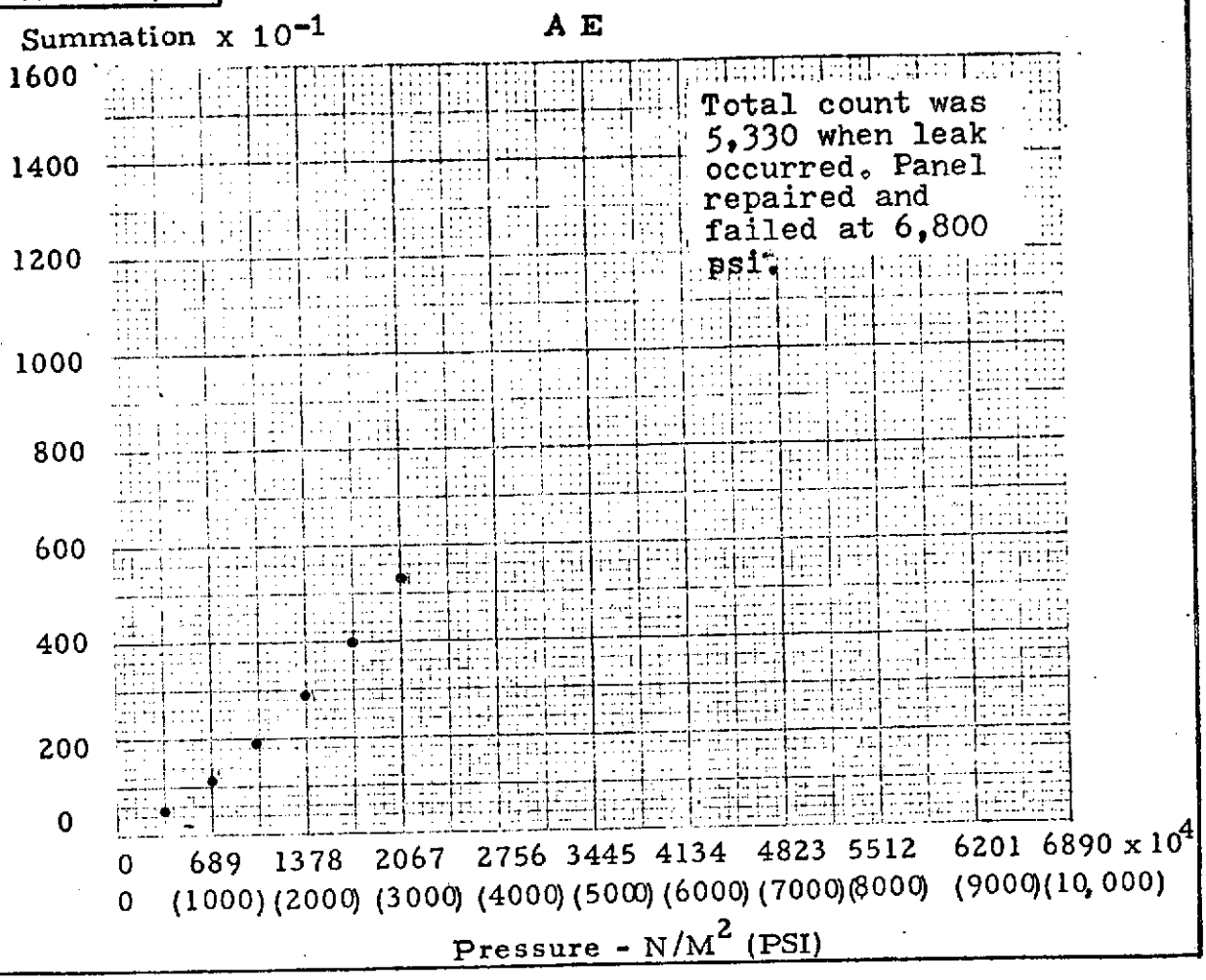
METALLOGRAPHIC ANALYSIS:

Failed weak bond. Magnification 50X.

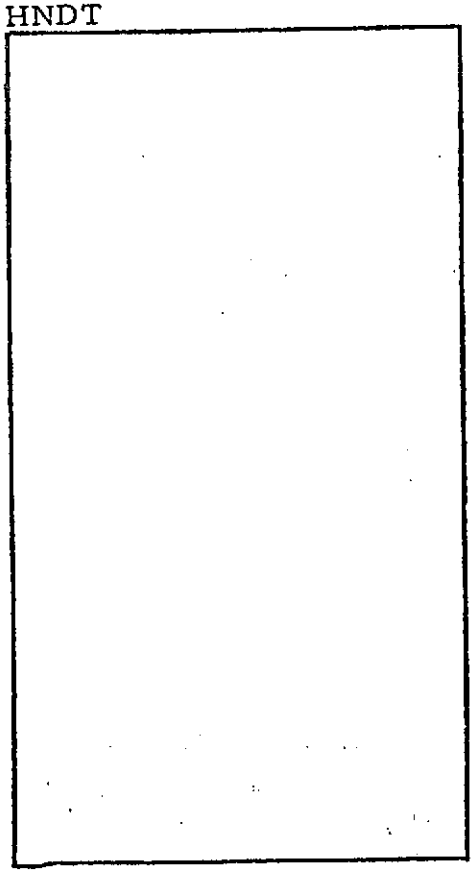
Section of unfailed full bond adjacent to planned weak bond area. Magnification 50X.

FIGURE A-2

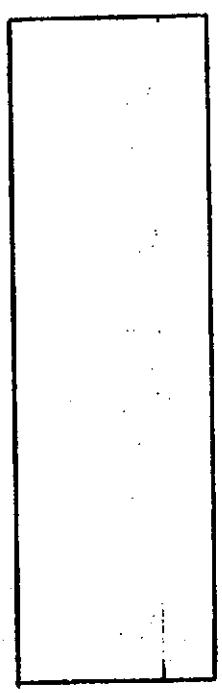
Panel No. N-07



HNDT



AE
FLAW LOCATOR
CENTER LAND



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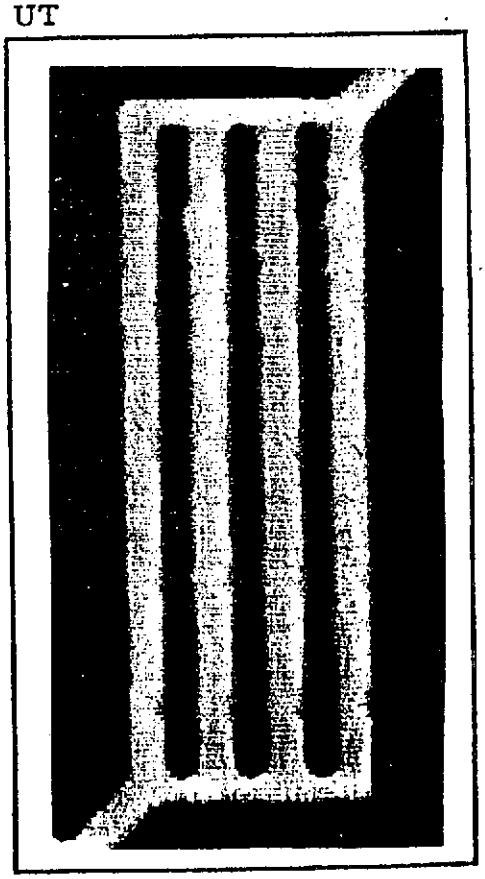
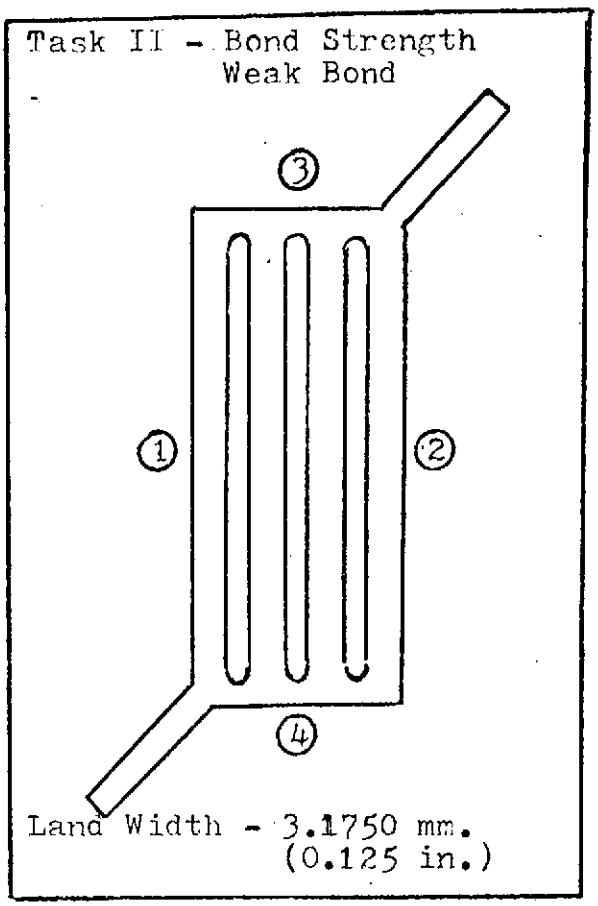


ELECTROFORMED PANEL NO. N-20



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.007 in. (0.1778 mm.)

THICKNESS:	MM.	INCHES
①	6.1976	0.2440
②	6.1773	0.2432
③	6.1773	0.2432
④	6.1570	0.2424

COVERPLATE

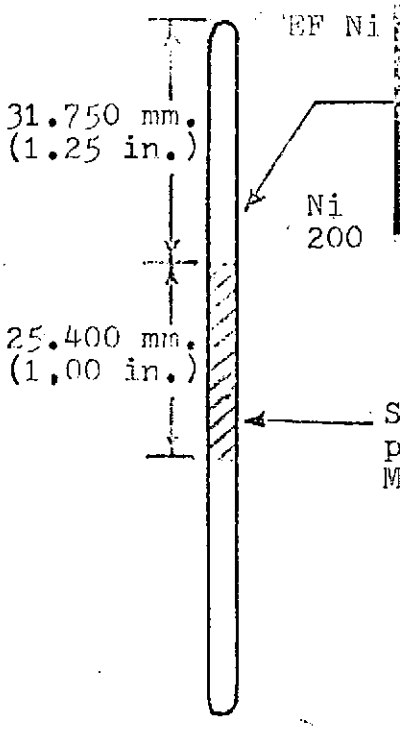
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.3132	0.0517
②	1.3614	0.0536
③	1.3792	0.0543
④	1.4376	0.0566

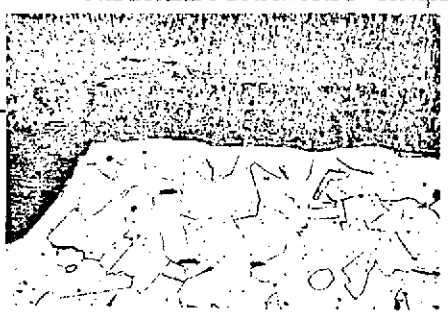
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 4.83×10^7 N/m^2 (7,000 psi)

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



Full bond area. Note initiation of bond tearing. Magnification 50X.

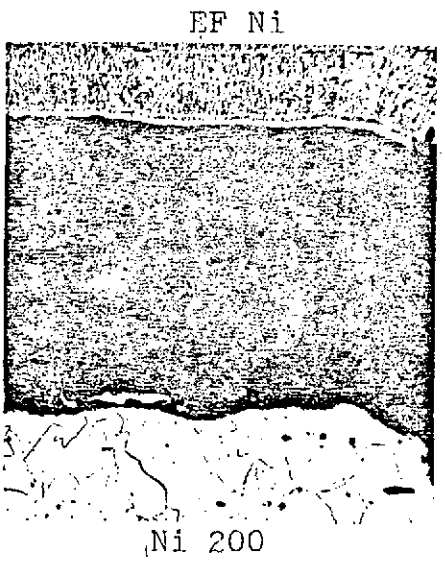
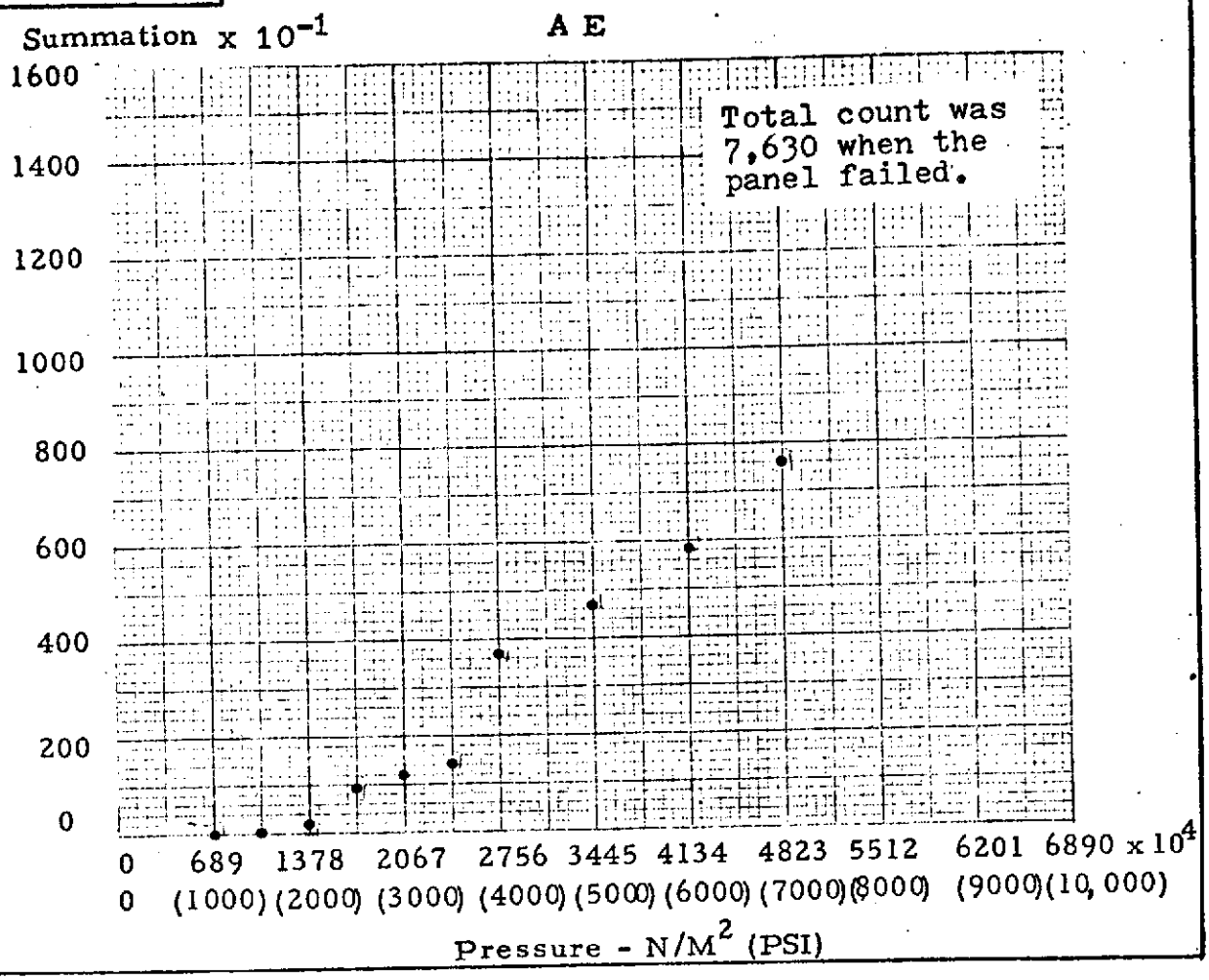
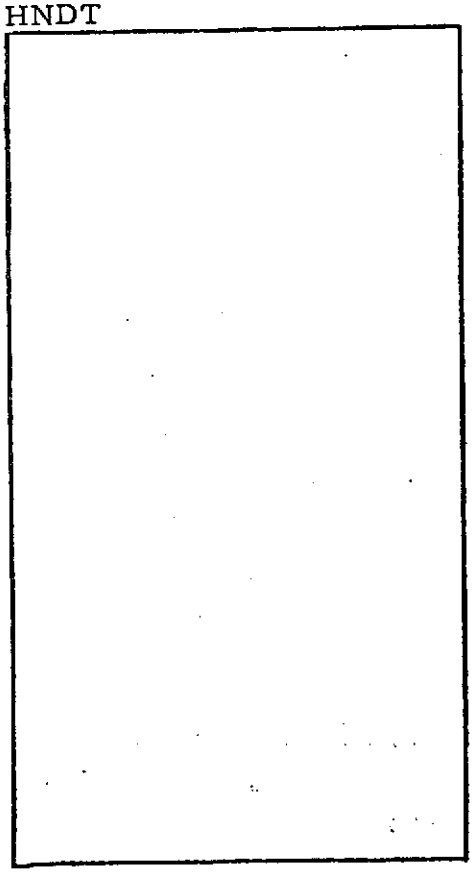


FIGURE A-3

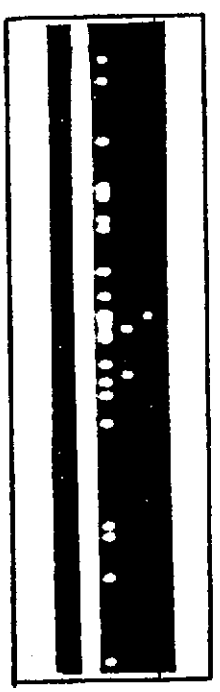
Panel No. N-20



HNDT



AE
FLAW LOCATOR
CENTER LAND



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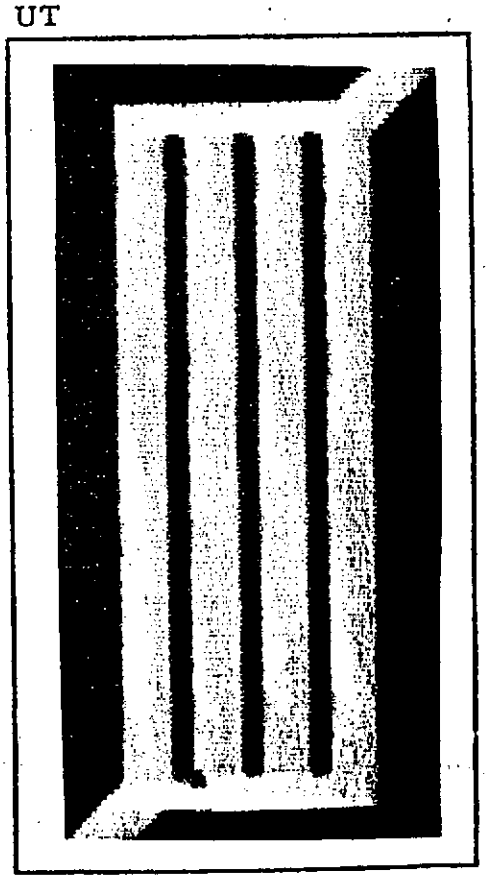
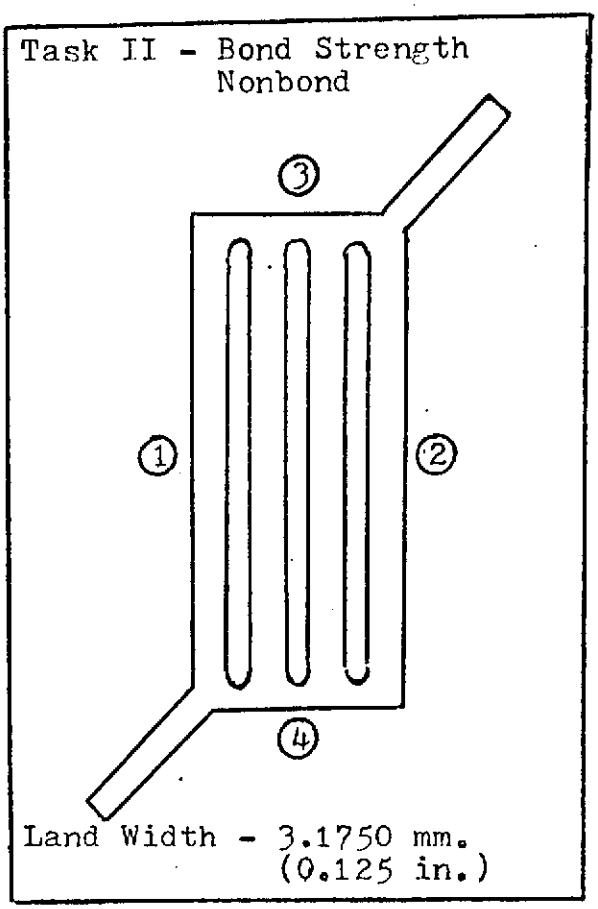


ELECTROFORMED PANEL NO. N-05 "A"



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.006 in. (0.1524 mm.)

THICKNESS:	MM.	INCHES
①	6.1722	0.2430
②	6.1239	0.2411
③	6.1544	0.2423
④	6.1468	0.2420

COVERPLATE

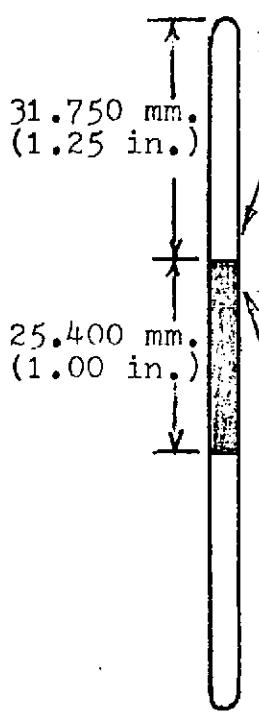
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.0973	0.0432
②	1.1735	0.0462
③	1.1557	0.0455
④	1.1252	0.0443

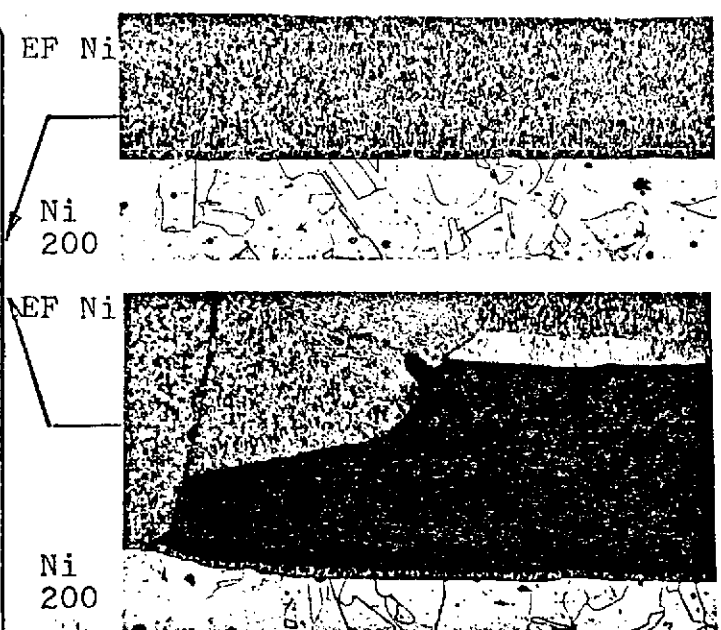
PRESSURE REQUIRED TO FAIL BOND:

Defect area bulged at a pressure of 1.38×10^7 N/m^2 (2,000 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

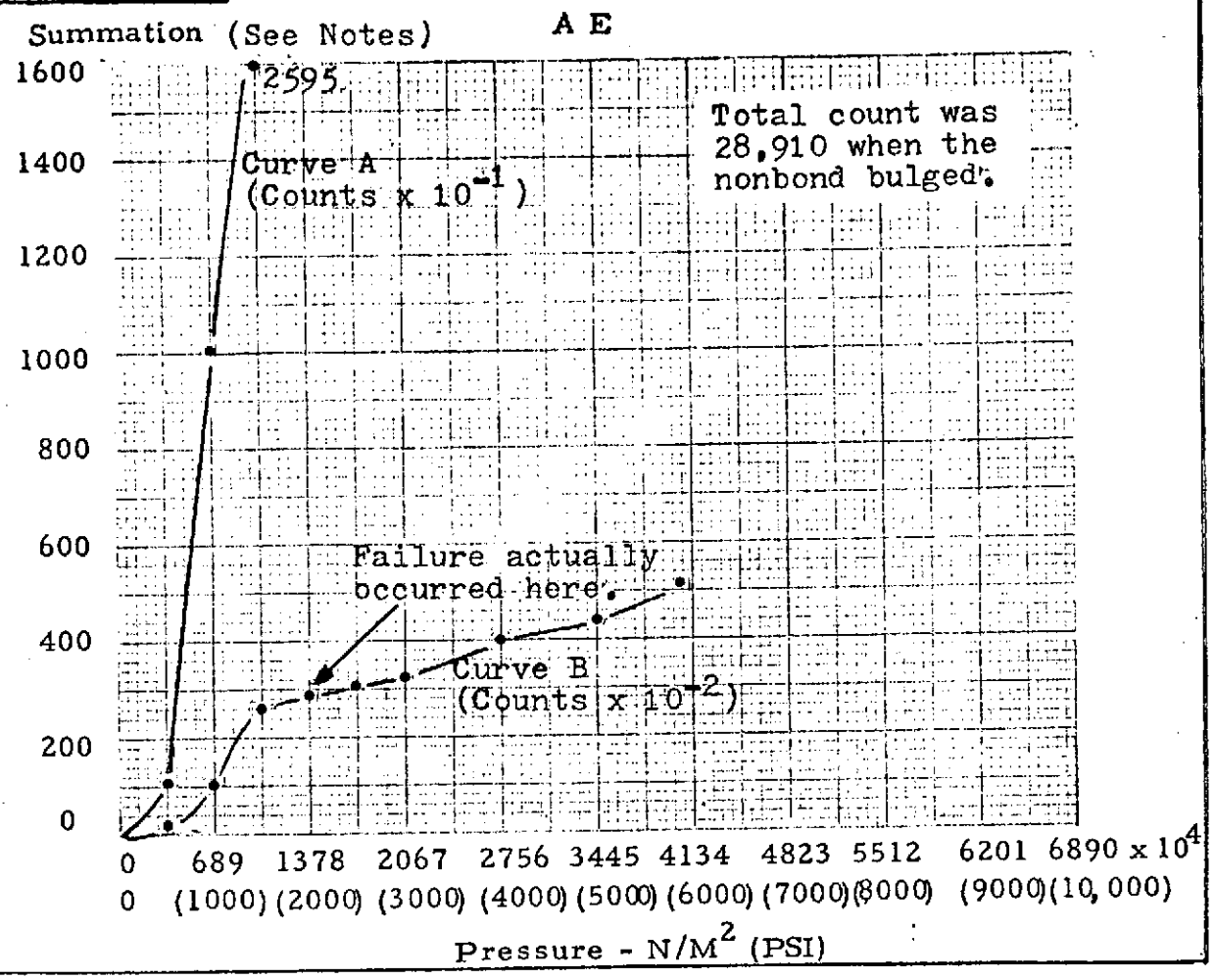


View of full bond area next to the planned nonbond defect. No failure is evident. Magnification 50X.

Section from end of planned nonbond defect showing separation of the EF Nickel and Nickel 200 surfaces. Magnification 50X.

FIGURE A-4

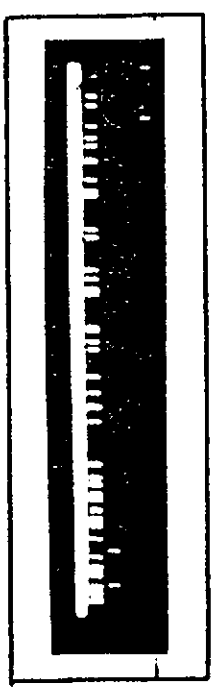
Panel No. N-05"A"



HNDT

Acoustic emission count was plotted with two multipliers to show the effect of the narrow unplanned tack bond along the left side of the planned nonbond. Curve A. Curve B shows entire count x 10^{-2} through defect bulge and into full bond failure along the land extremities.

AE
FLAW LOCATOR
CENTER LAND



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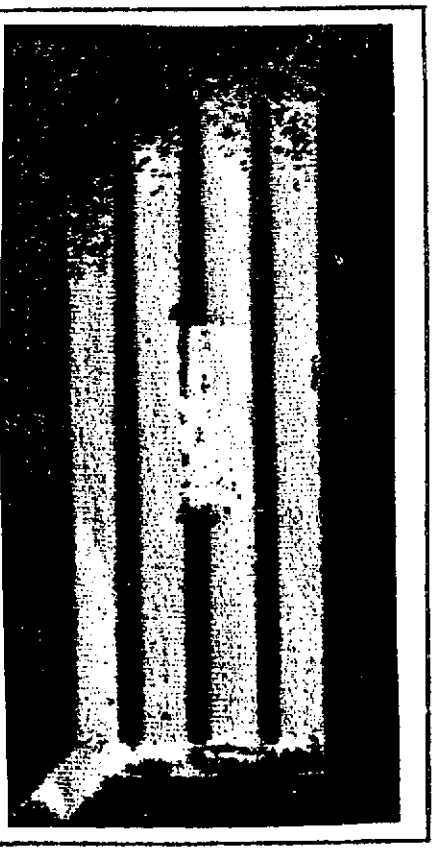
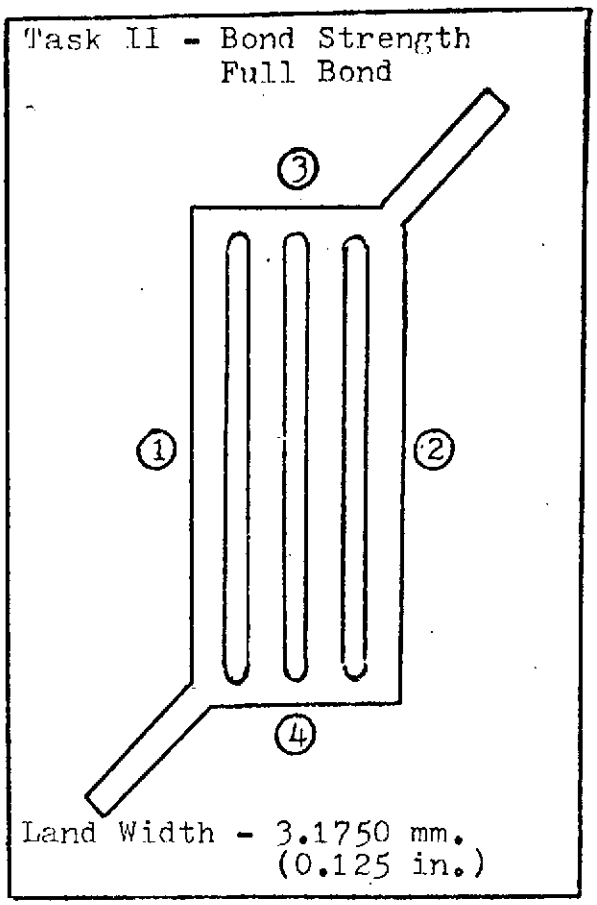


ELECTROFORMED PANEL NO. C-07N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.004 in. (0.1016 mm.)

THICKNESS:	MM.	INCHES
①	6.5735	0.2588
②	6.5862	0.2593
③	6.6294	0.2610
④	6.5278	0.2570

COVERPLATE

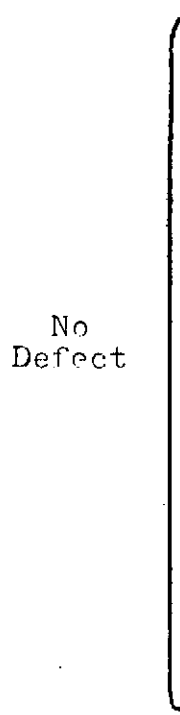
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4986	0.0590
②	1.5113	0.0595
③	1.4122	0.0556
④	1.5494	0.0610

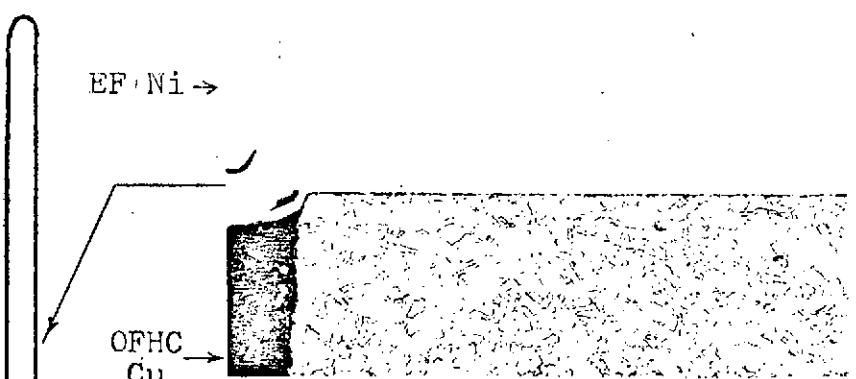
PRESSURE REQUIRED TO FAIL BOND:

Bond did not fail at a pressure of 6.90×10^7 N/m^2 (10,000 psi)

CENTER LAND DEFECT



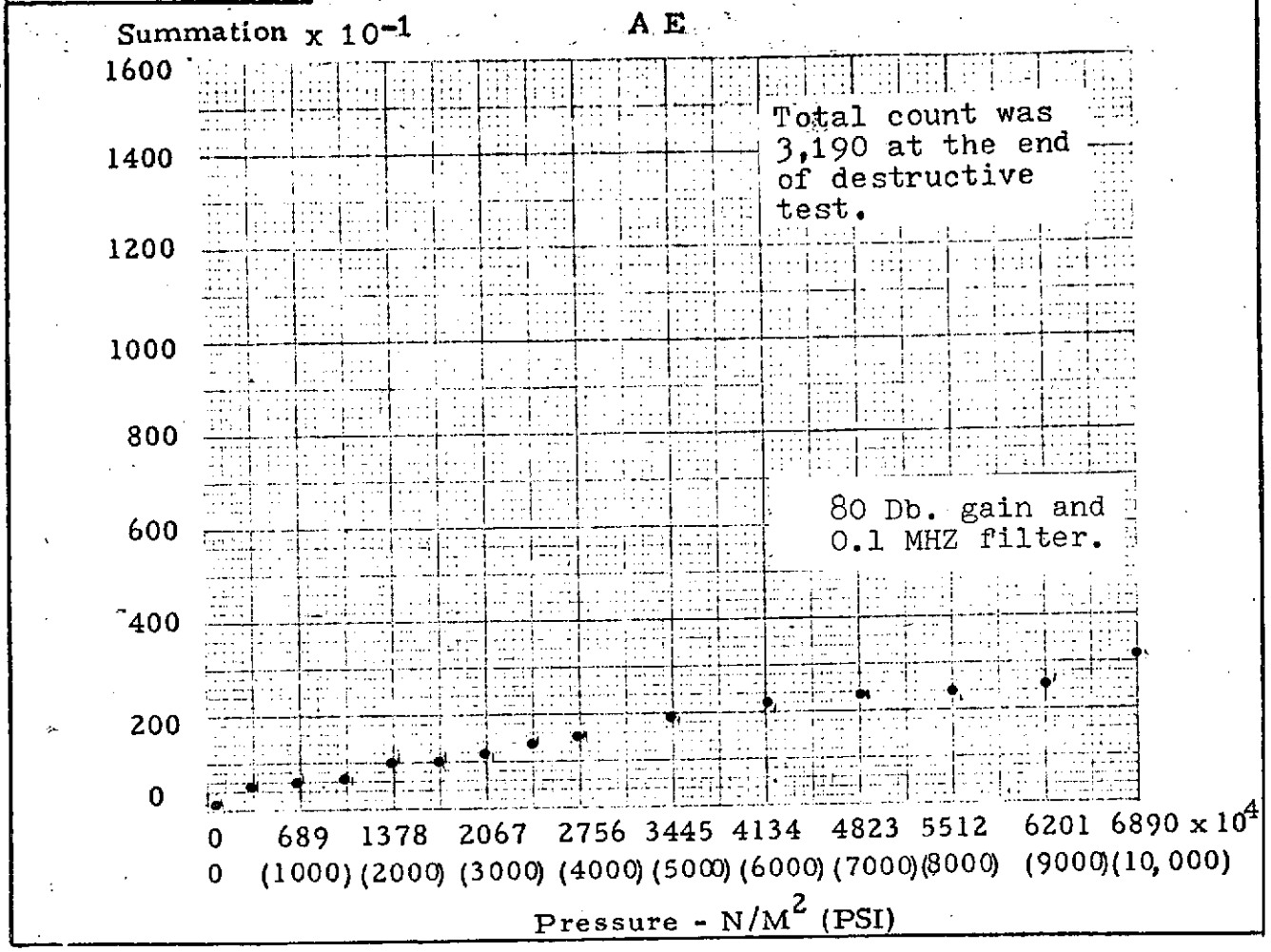
METALLOGRAPHIC ANALYSIS:



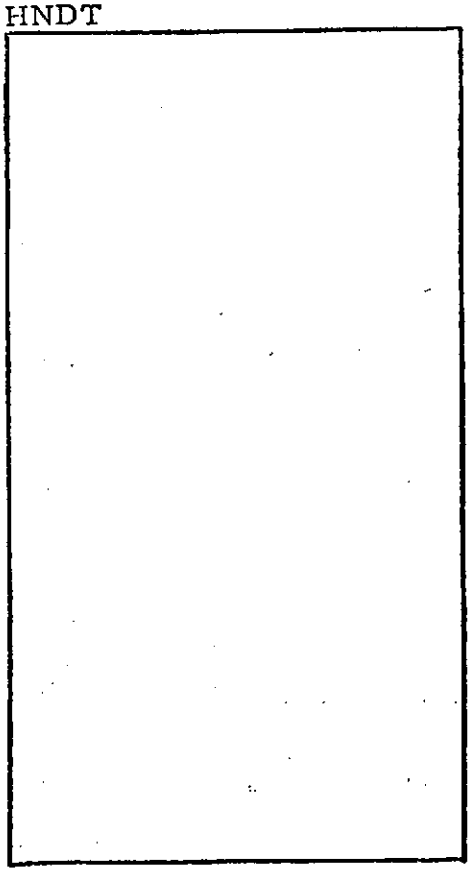
Section of center land showing full bond after pressurization. No failure was noted. Magnification 50X.

FIGURE A-5

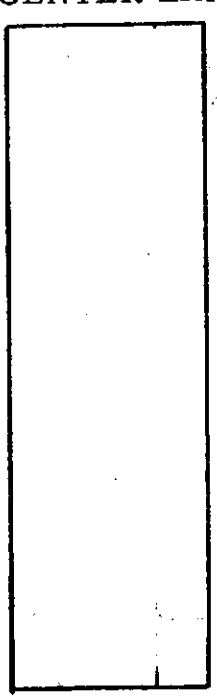
Panel No. C-07N



HNDT



AE
FLAW LOCATOR
CENTER LAND



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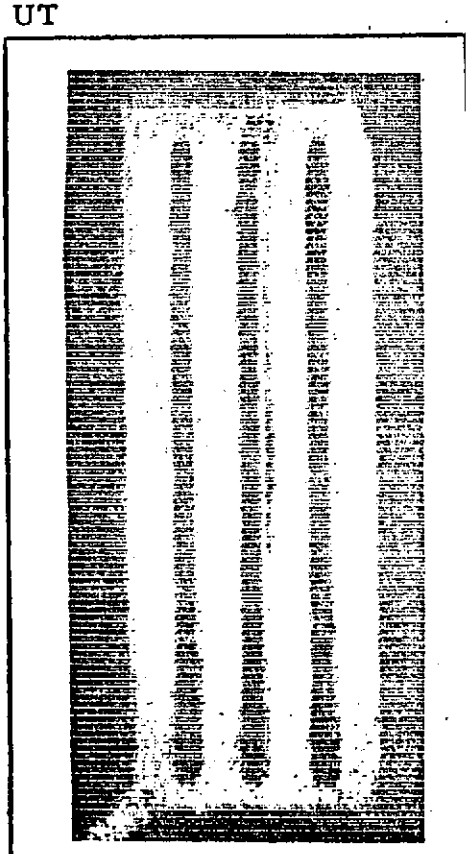
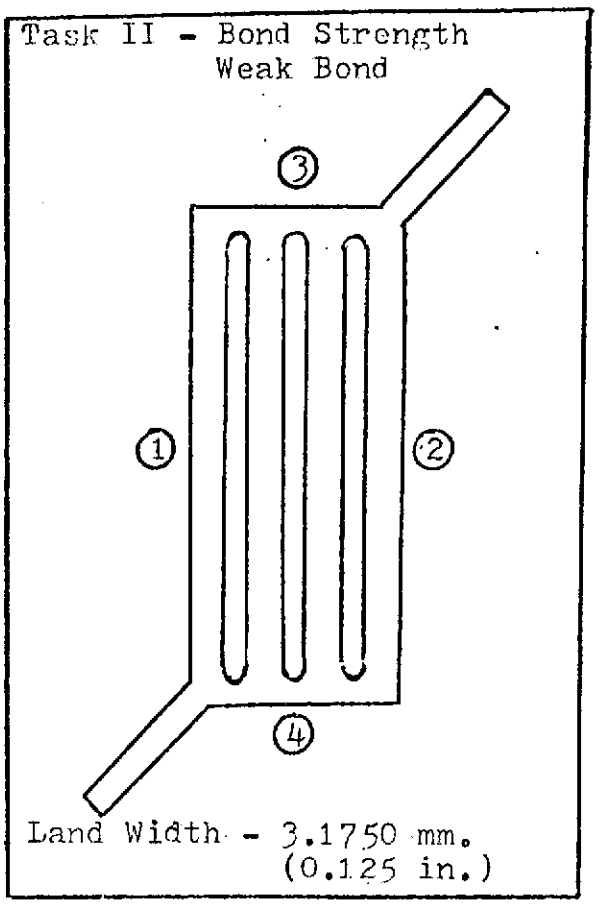


ELECTROFORMED PANEL NO. C-1[illegible]



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.6294	0.2610
②	6.6218	0.2607
③	6.6091	0.2602
④	6.6802	0.2630

COVERPLATE

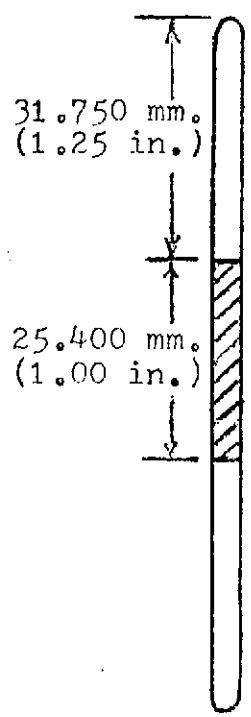
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.3970	0.0550
②	1.4021	0.0552
③	1.3919	0.0548
④	1.3564	0.0534

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.76×10^7 N/m^2 (4,000 psi)

CENTER LAND DEFECT

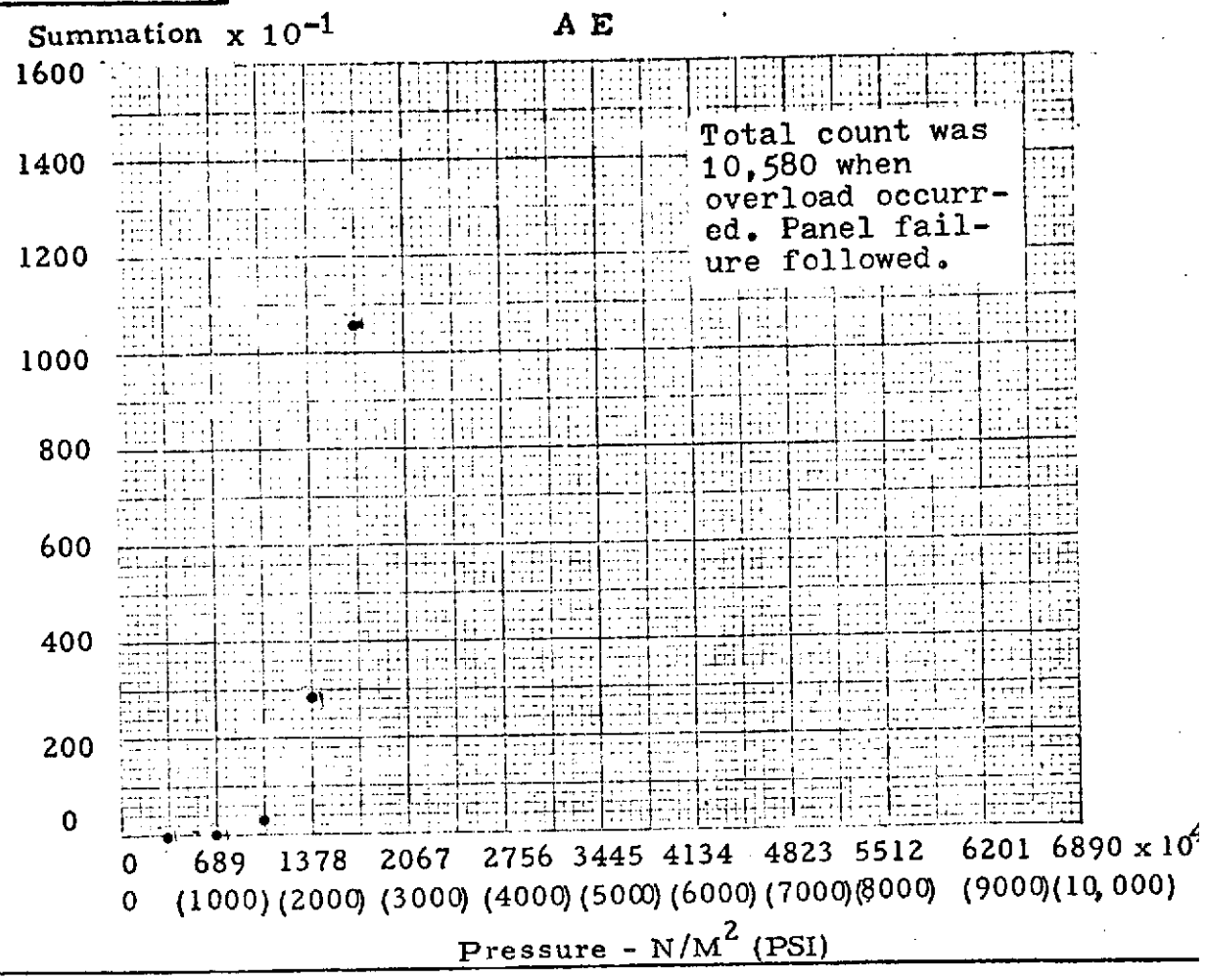


METALLOGRAPHIC ANALYSIS:

This panel was not metallurically sectioned. The process used to produce the weak bond on this panel was not used in subsequent panels. See results for panel C-14N, Figure A-7, for the selected weak bond process.

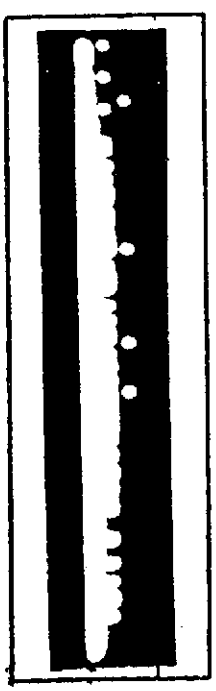
FIGURE A-6

Panel No. C-13N

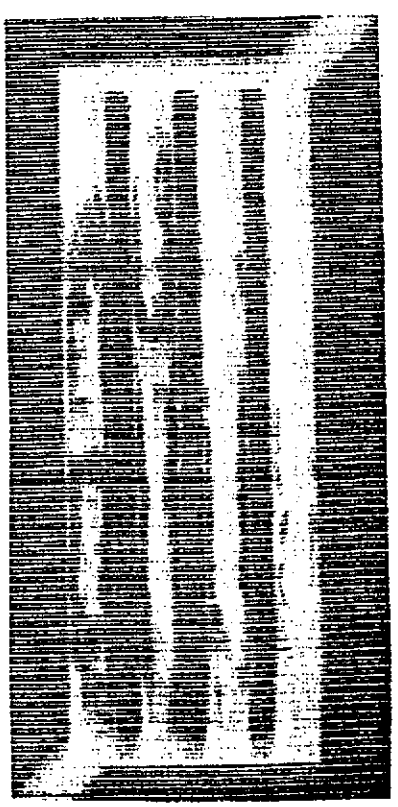


HNDT

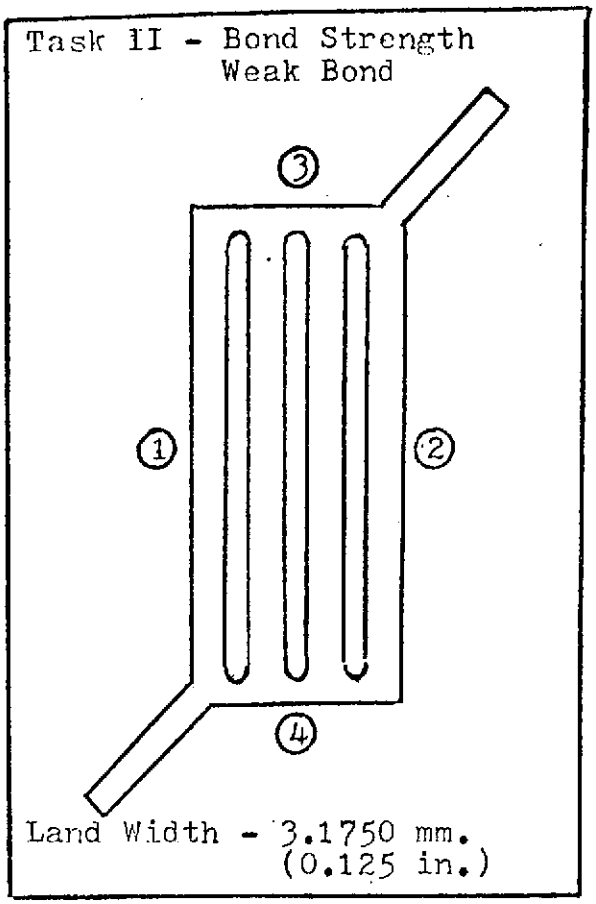
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-14N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.005 in. (0.1270 mm.)

THICKNESS:	MM.	INCHES
①	6.5786	0.2590
②	6.6294	0.2610
③	6.5329	0.2572
④	6.6802	0.2630

COVERPLATE

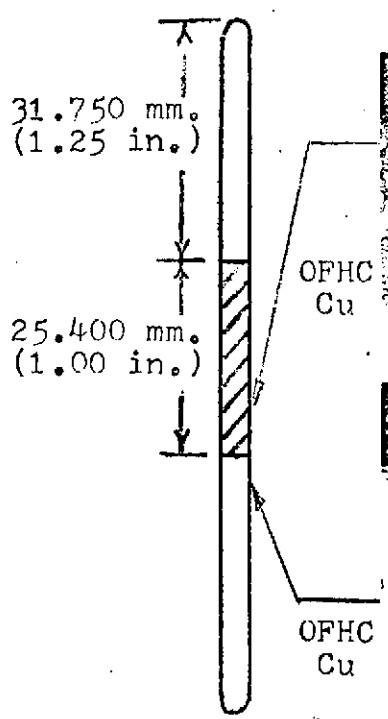
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4173	0.0558
②	1.3919	0.0548
③	1.4148	0.0557
④	1.3614	0.0536

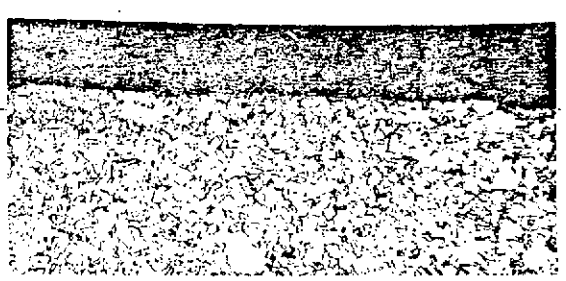
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.55×10^7 N/m^2 (3,700 psi)

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

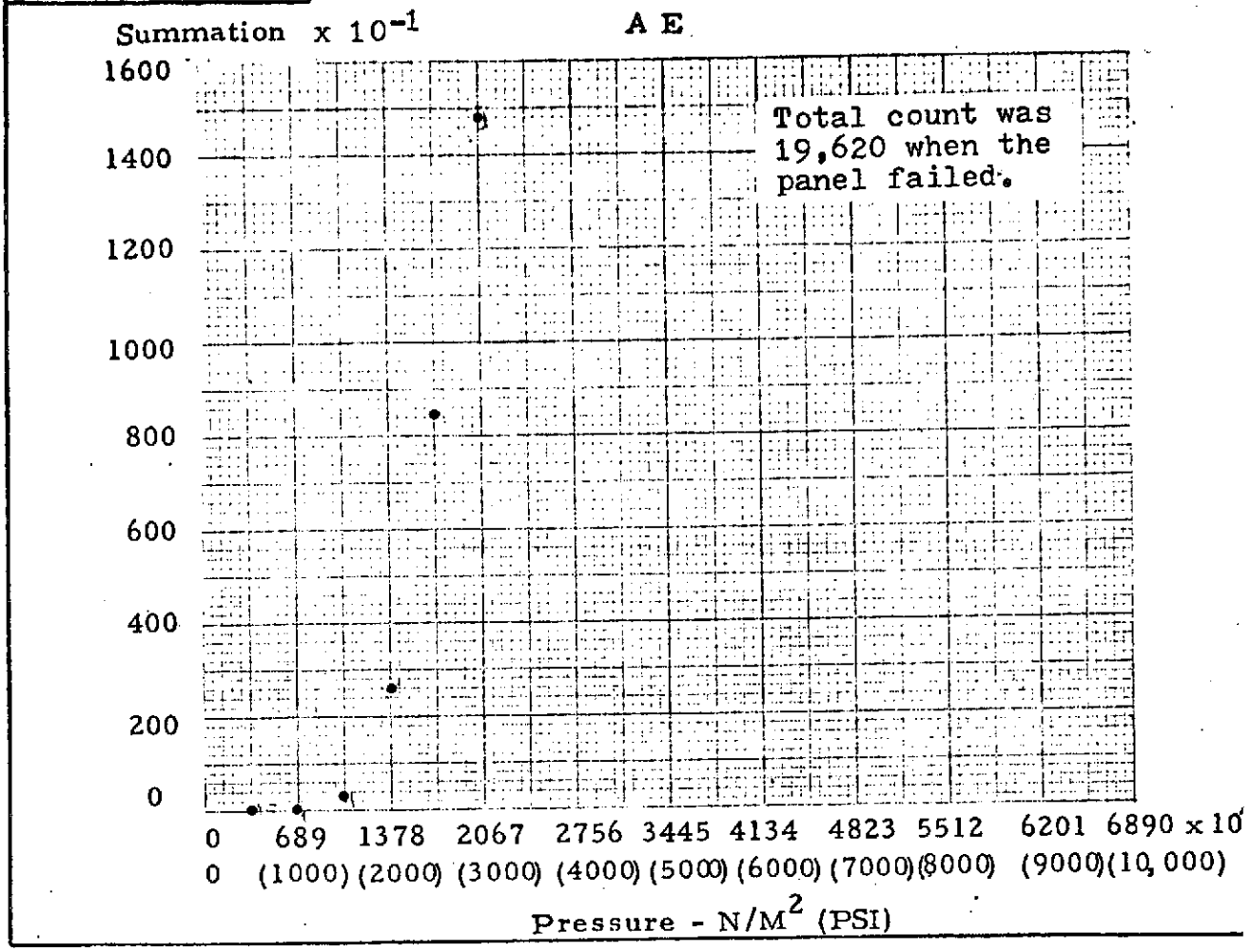


Section of baseplate portion of planned weak bond. Minor metal disturbance indicates a very weak bond. Magnification 50X. Nickel coverplate bulged out of view.

Section of baseplate portion of planned full bond next to the weak bond. Metal tearing was noted in this region. Magnification 200X.

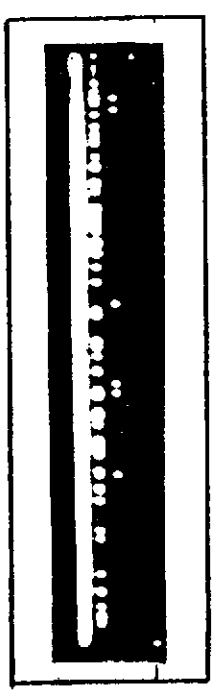
FIGURE A-7

Panel No. C-14N

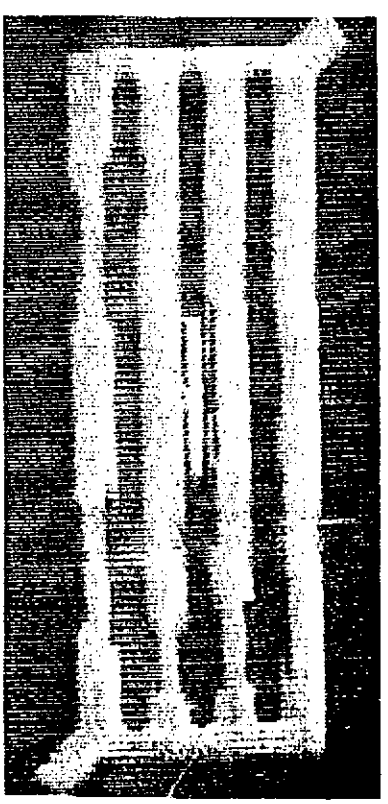


HNDT

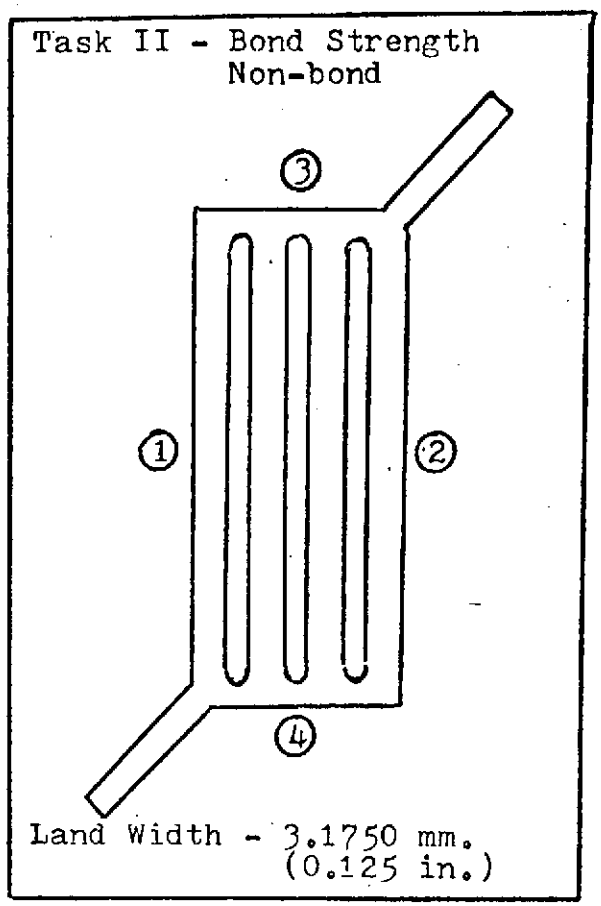
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-15N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.6853	0.2632
②	6.6497	0.2618
③	6.6802	0.2630
④	6.6294	0.2610

COVERPLATE

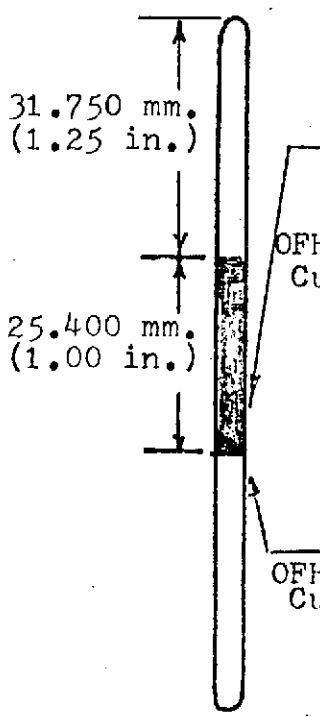
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4021	0.0552
②	1.5037	0.0592
③	1.3995	0.0551
④	1.4427	0.0568

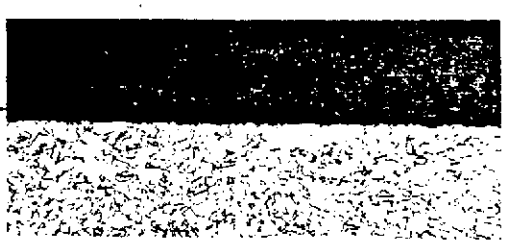
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.76×10^7 N/m^2 (4,000 psi). Bulging started at approximately 2.07×10^7 N/m^2 (3,000 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

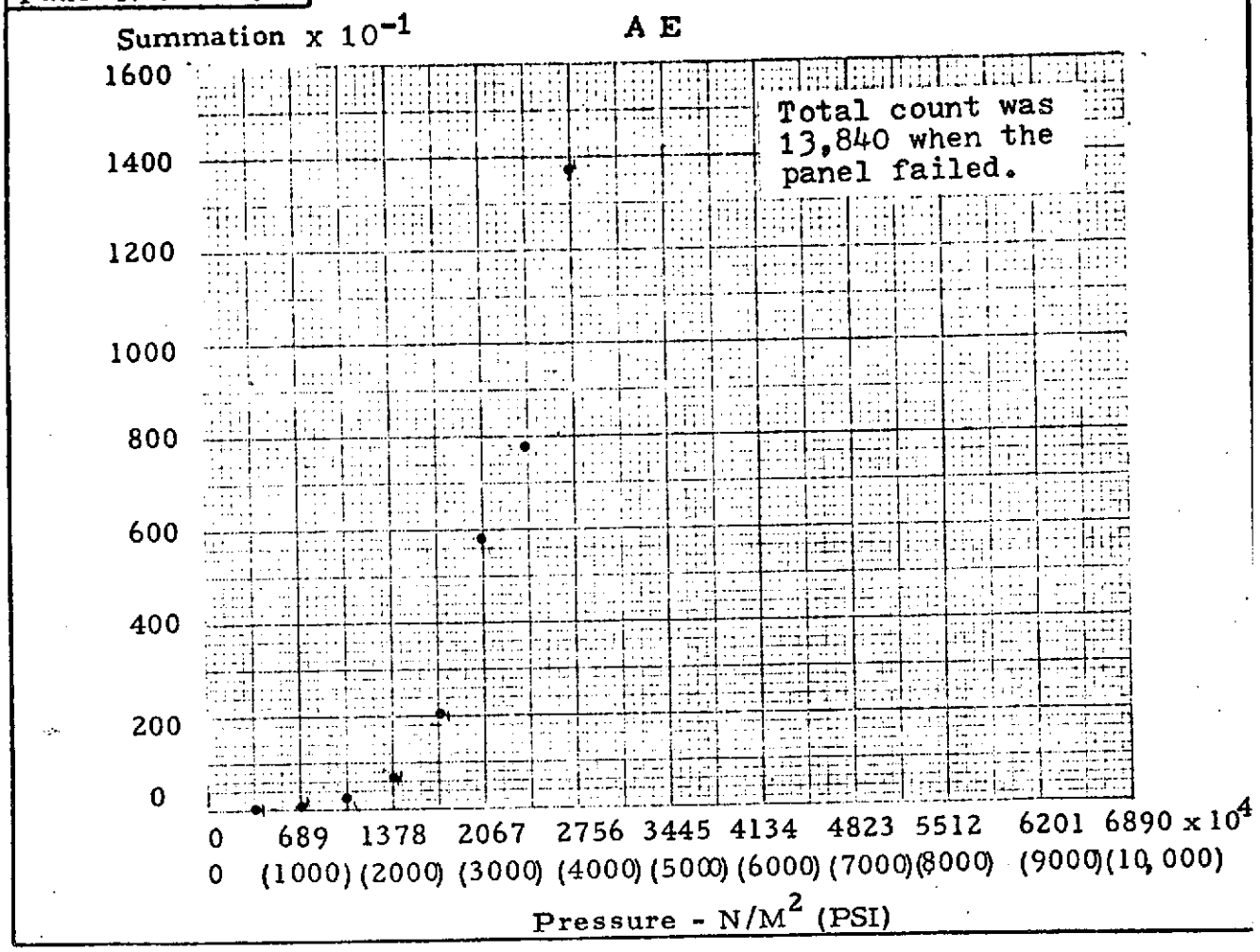


Section of baseplate in planned nonbond area. Coverplate is bulged out of view. Magnification 50X.

Section of baseplate in planned full bond region next to the nonbond. Failure of nonbond propagated into this region. Magnification 50X.

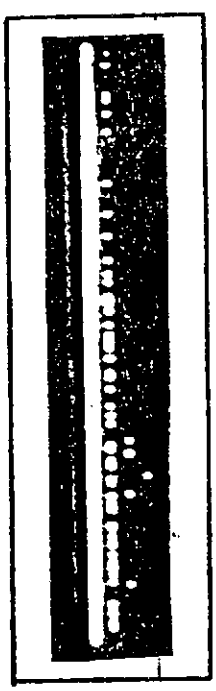
FIGURE A-8

Panel No. C-15N

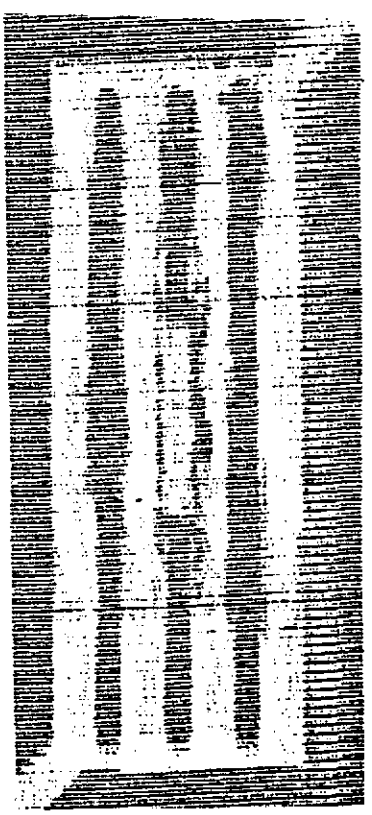


HNDT

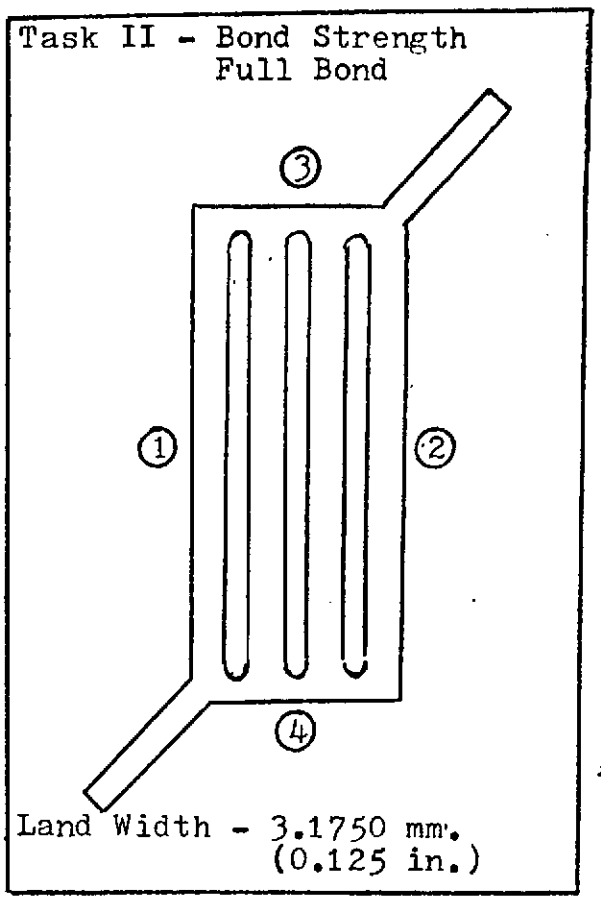
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-02C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION:
0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.7259	0.2648
②	6.7310	0.2650
③	6.7310	0.2650
④	6.7310	0.2650

COVERPLATE

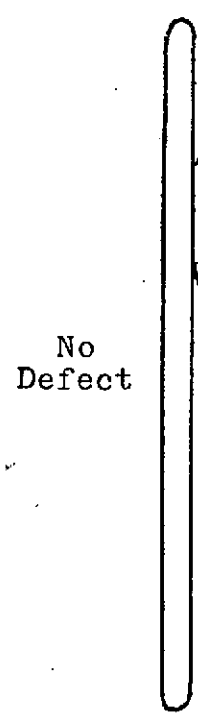
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.3157	0.0518
②	1.3284	0.0523
③	1.2954	0.0510
④	1.3284	0.0523

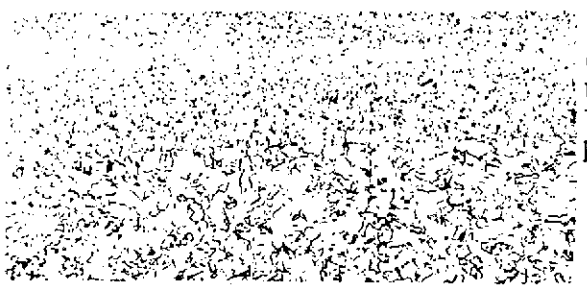
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 6.38×10^7 N/m^2 (9,250 psi)

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

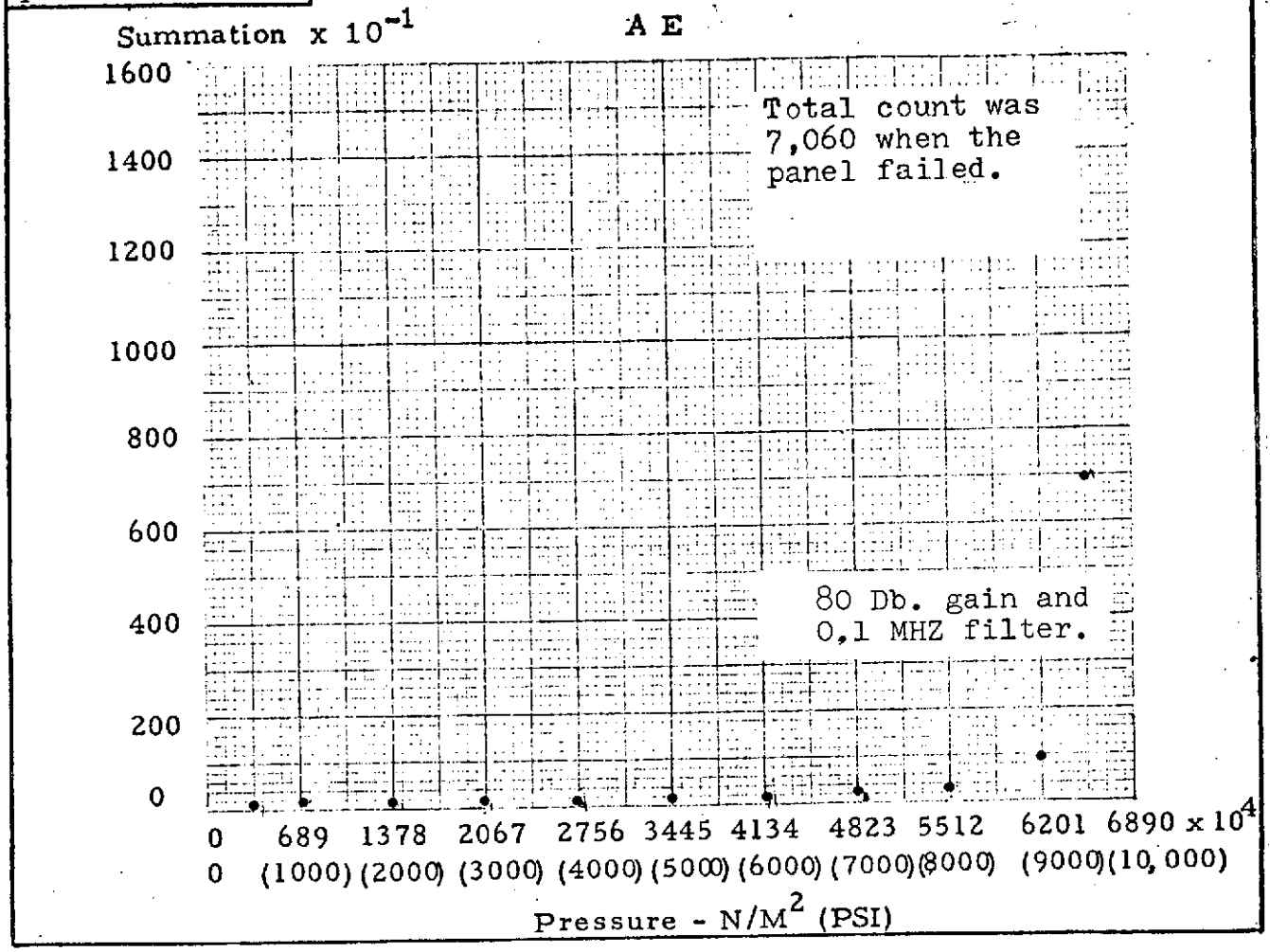


Section showing unfailed full bond after test. Magnification 50X.

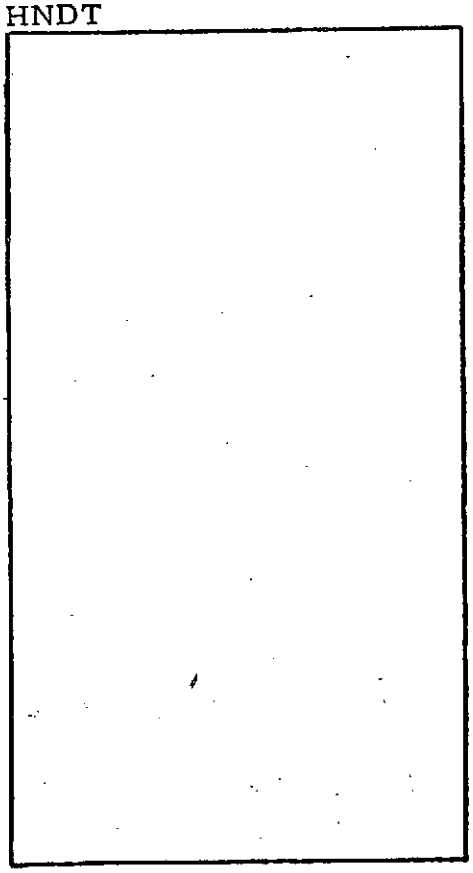
Section of failed full bond after destructive test. Magnification 50X.

FIGURE A-9

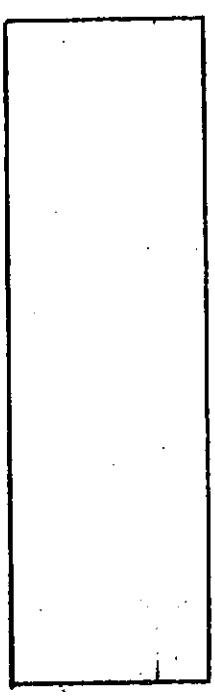
Panel No. C-02C



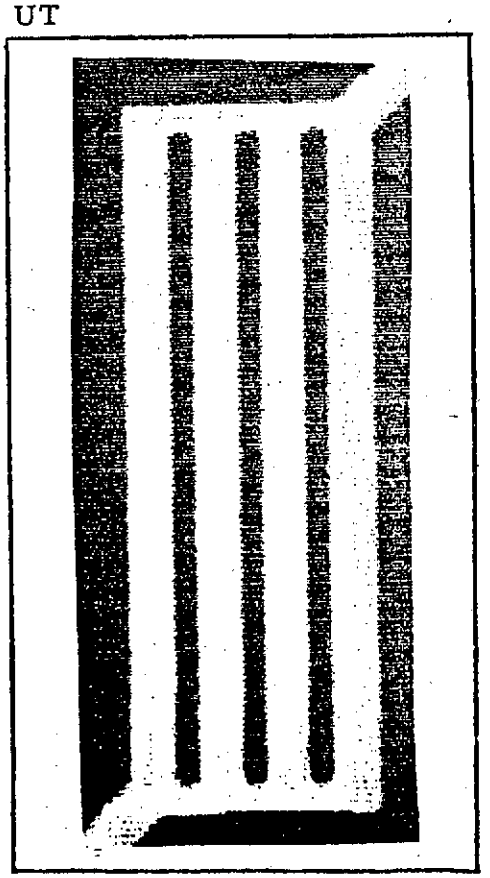
HNDT



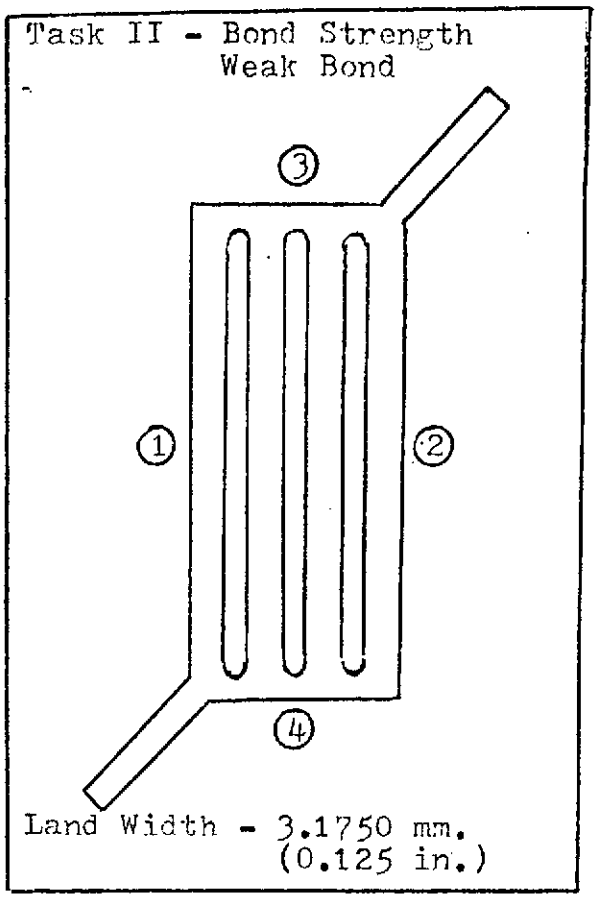
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-05C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.004 in. (0.1016 mm.)

THICKNESS:	MM.	INCHES
①	6.4262	0.2530
②	6.4745	0.2549
③	6.4719	0.2548
④	6.4186	0.2527

COVERPLATE

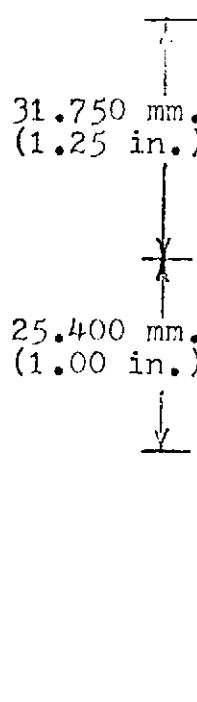
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2929	0.0509
②	1.2268	0.0483
③	1.2421	0.0489
④	1.2827	0.0505

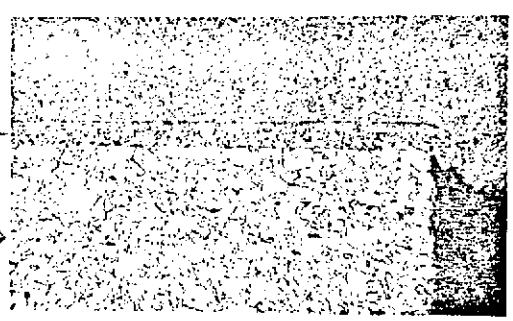
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 1.86×10^7 N/m^2 (2,700 psi)

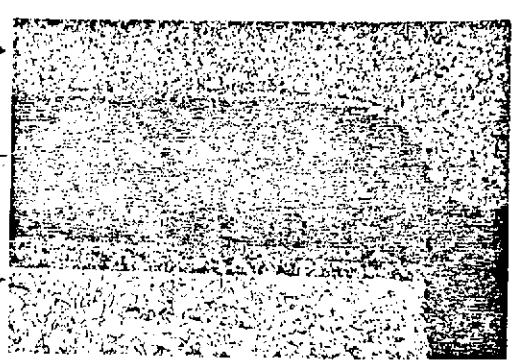
CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



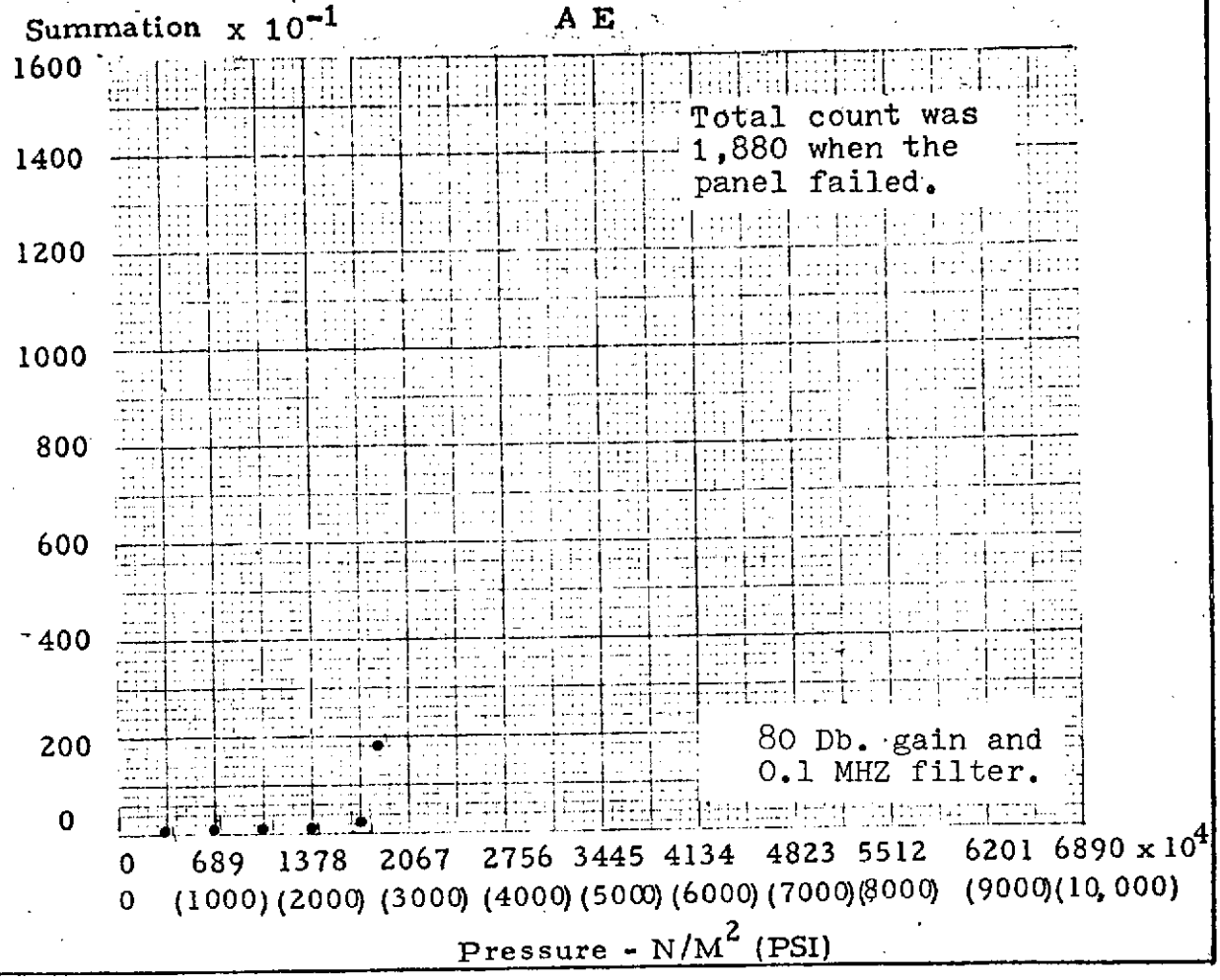
Section showing unfailed full bond. Magnification 50X.



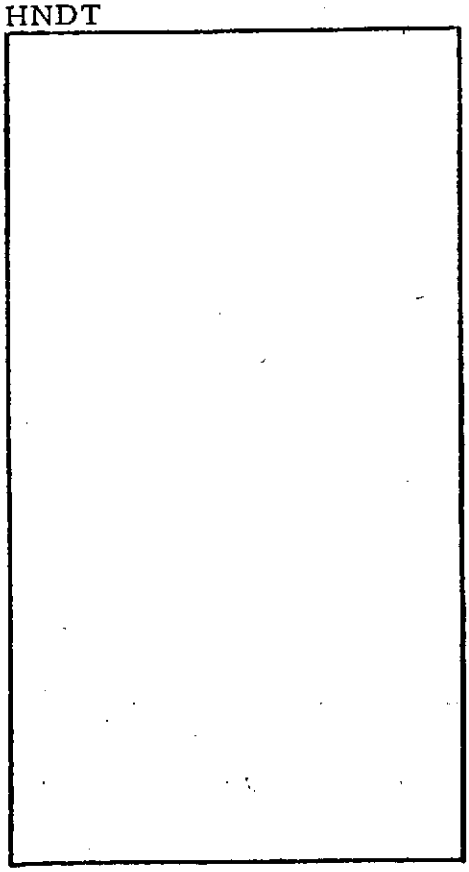
Section of weak bond after failure. Magnification 50X.

FIGURE A-10

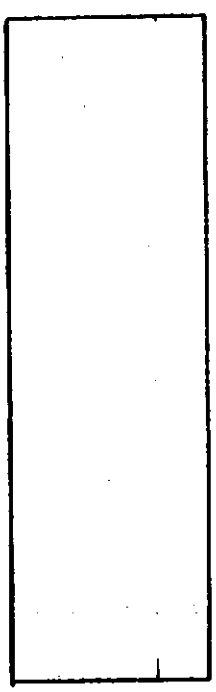
Panel No. C-05C



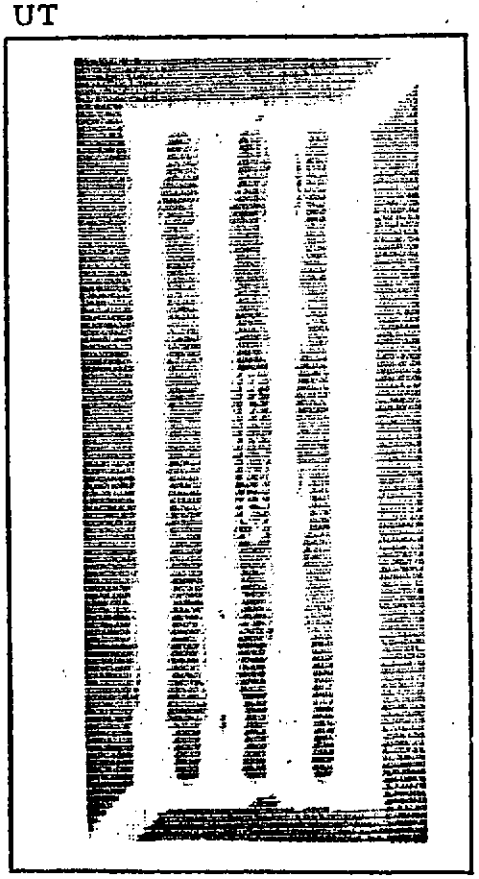
HNDT



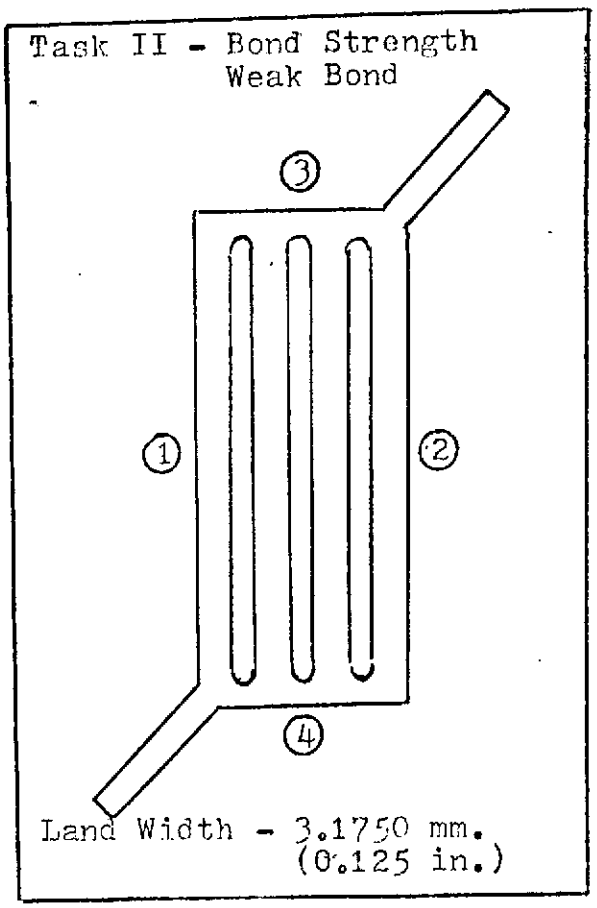
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-10C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.5735	0.2588
②	6.5735	0.2588
③	6.6269	0.2609
④	6.5303	0.2571

COVERPLATE

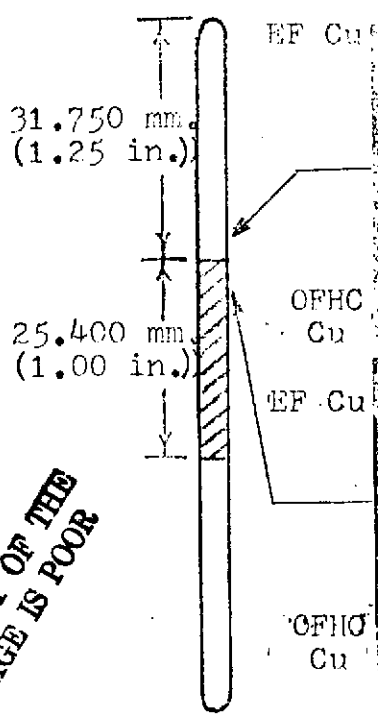
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2852	0.0506
②	1.3157	0.0518
③	1.2700	0.0500
④	1.3589	0.0535

PRESSURE REQUIRED TO FAIL BOND:

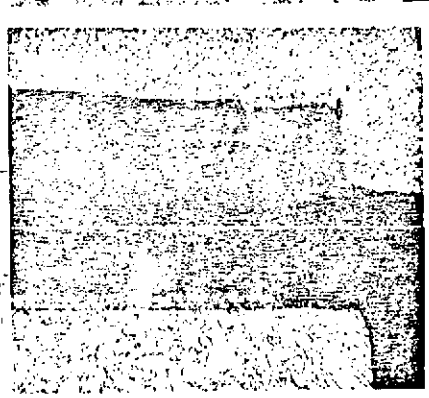
Bond failed at a pressure of 3.80×10^7 N/m^2 (5,500 psi)

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

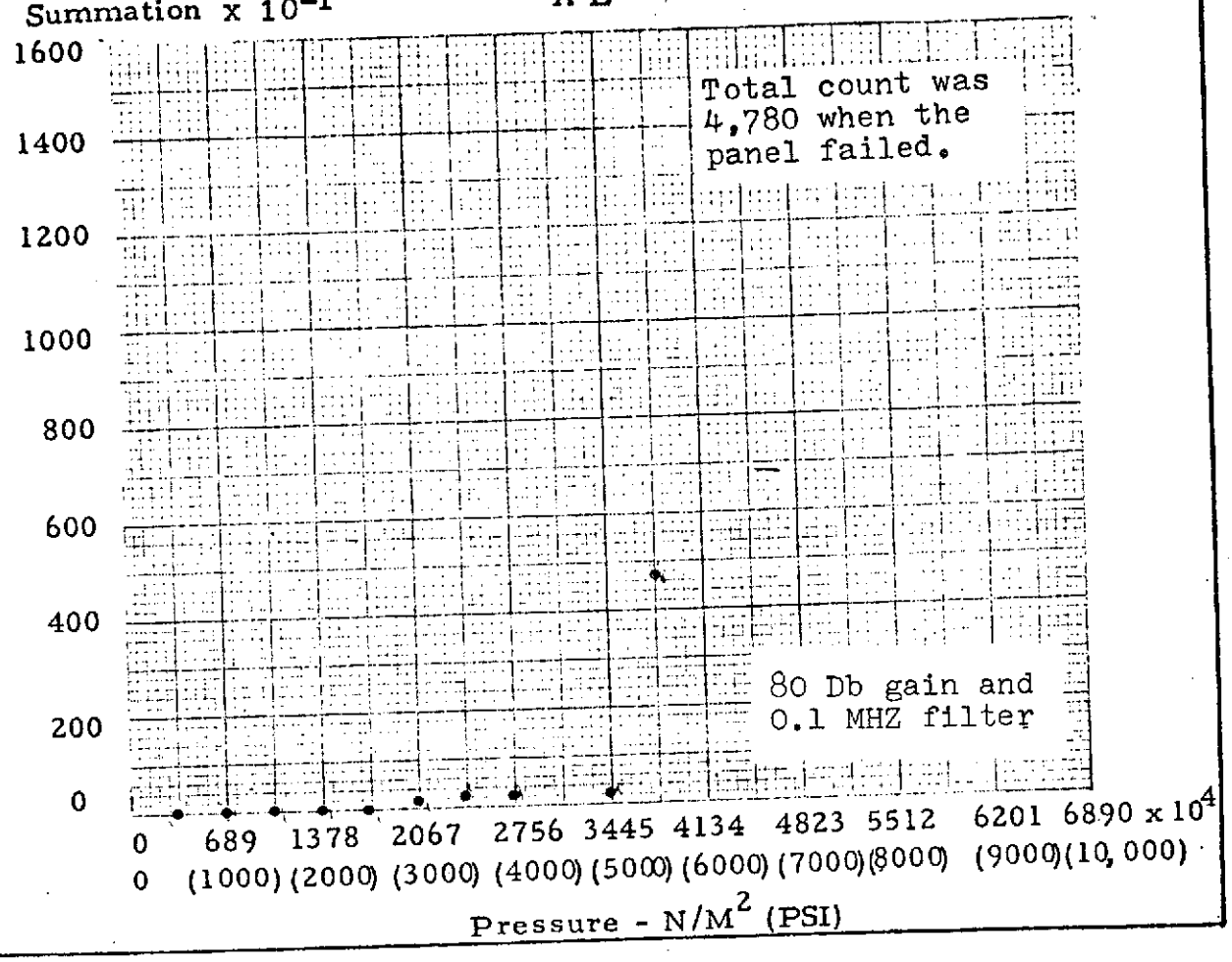
Full bond area of land showing no bond failure. Magnification 50X.



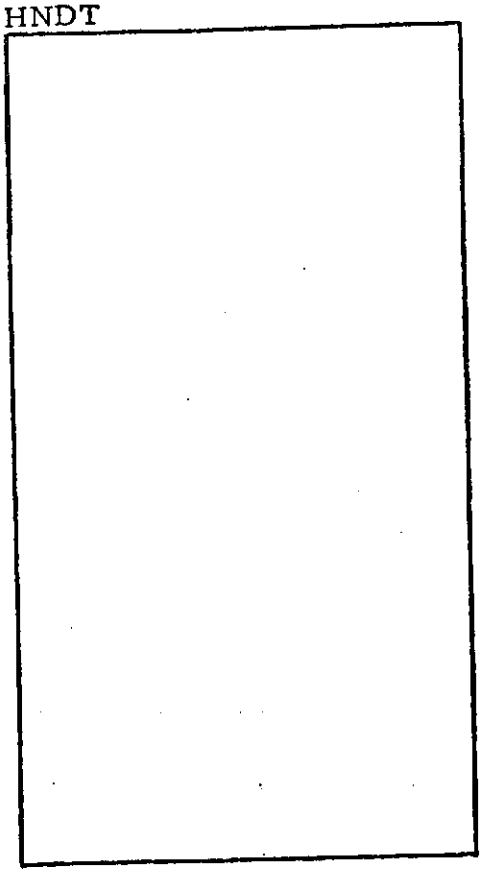
Section of weak bond planned defect. Bond failure occurred. Magnification 50X.

FIGURE A-11

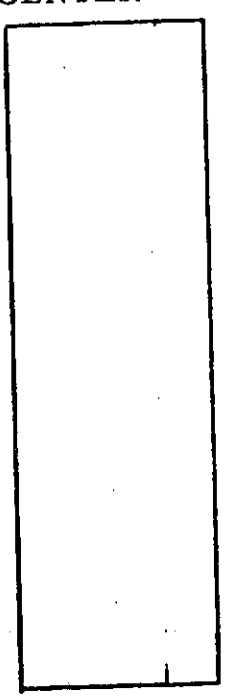
Panel No. C-10C



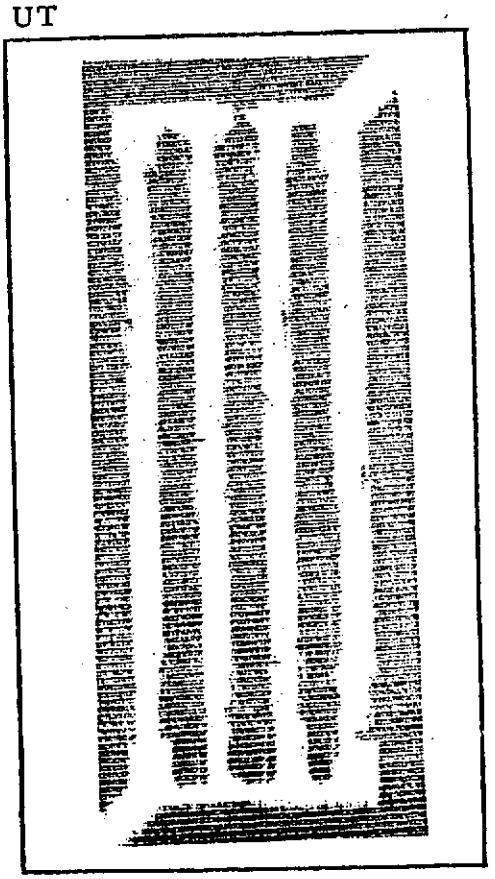
HNDT



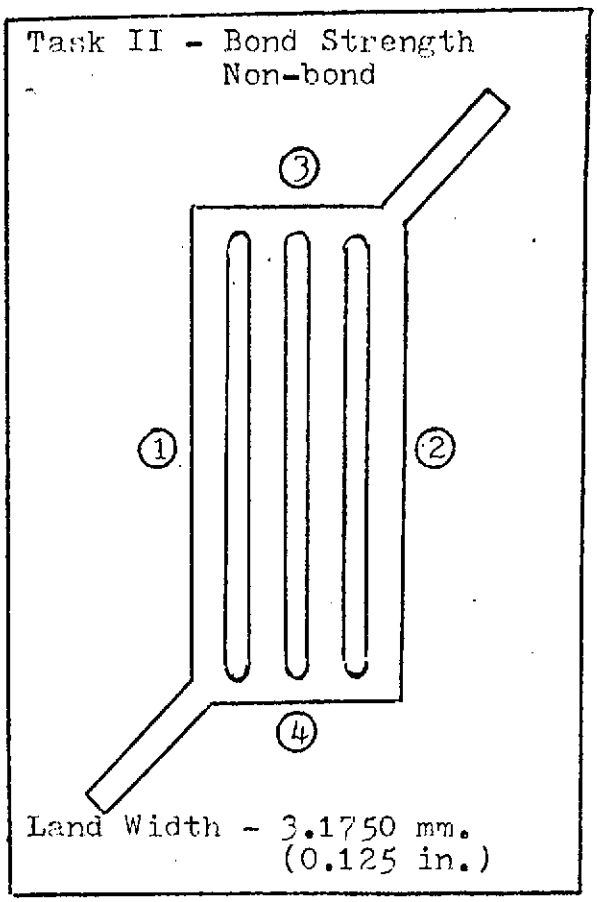
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-11C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.5380	0.2574
②	6.6040	0.2600
③	6.5811	0.2591
④	6.5913	0.2595

COVERPLATE

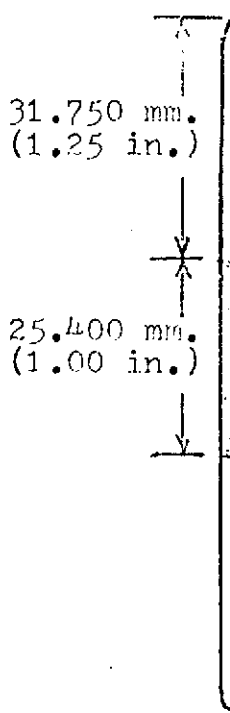
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.3233	0.0521
②	1.2776	0.0503
③	1.2624	0.0497
④	1.2675	0.0499

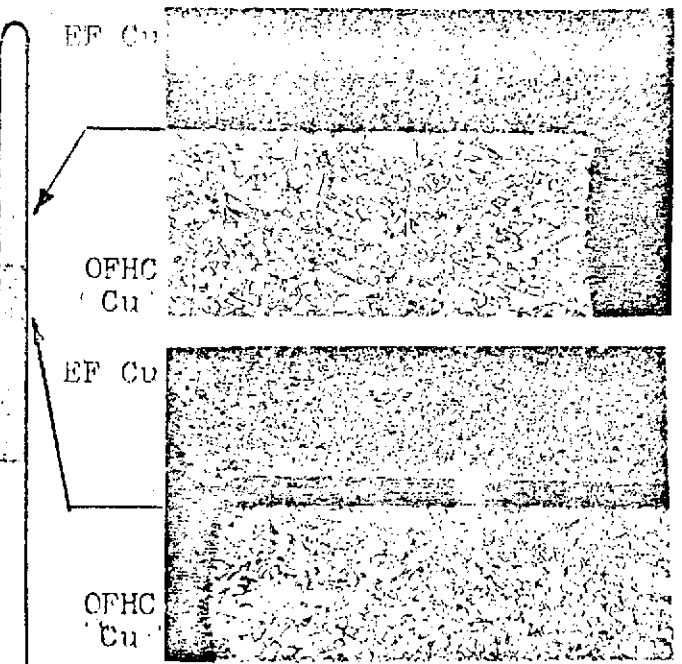
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 1.04×10^7 N/m^2 (1,500 psi)

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

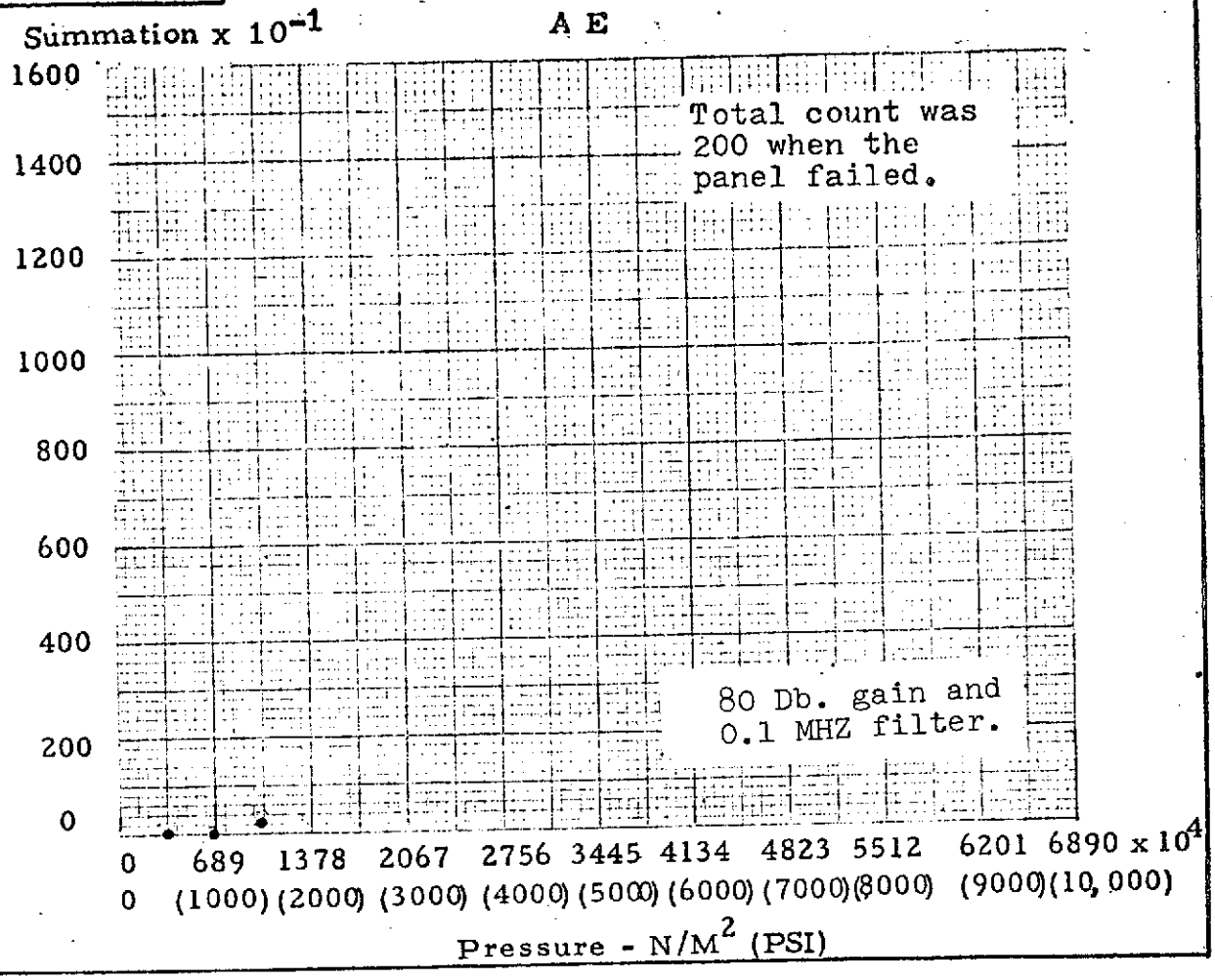


Full bond area showing no failure after test. Magnification 50X.

Planned nonbond which separated as expected during pressurization. Magnification 50X.

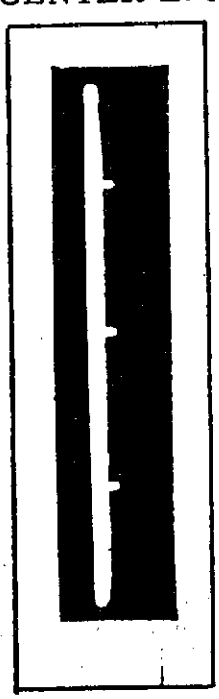
FIGURE A-12

Panel No. C-11C

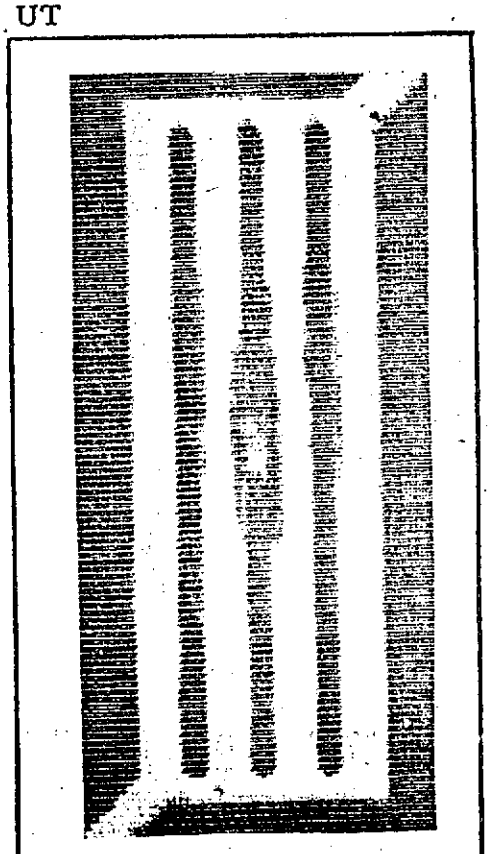


HNDT

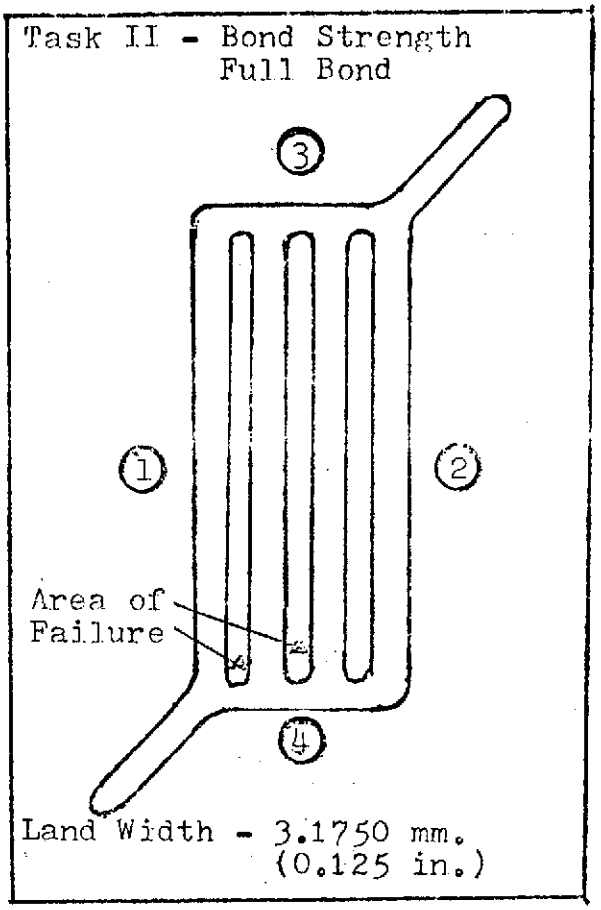
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-03



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.5735	0.2588
②	6.5405	0.2575
③	6.5913	0.2595
④	6.5126	0.2564

COVERPLATE

MATERIAL: 304L Stainless Steel

THICKNESS:	MM.	INCHES
①	1.2243	0.0482
②	1.2268	0.0483
③	1.2268	0.0483
④	1.2243	0.0482

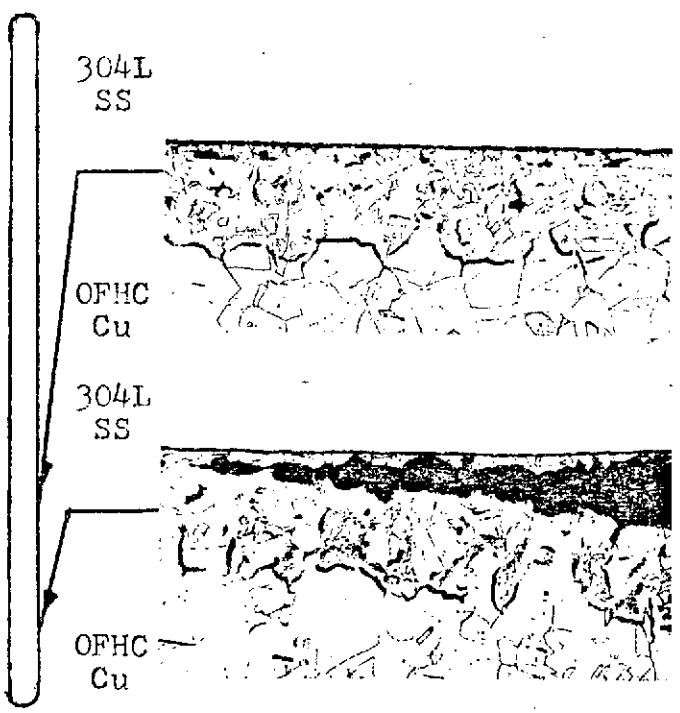
PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 2.76×10^7 N/m^2 (4,000 psi).

CENTER LAND DEFECT

No Defect

METALLOGRAPHIC ANALYSIS:

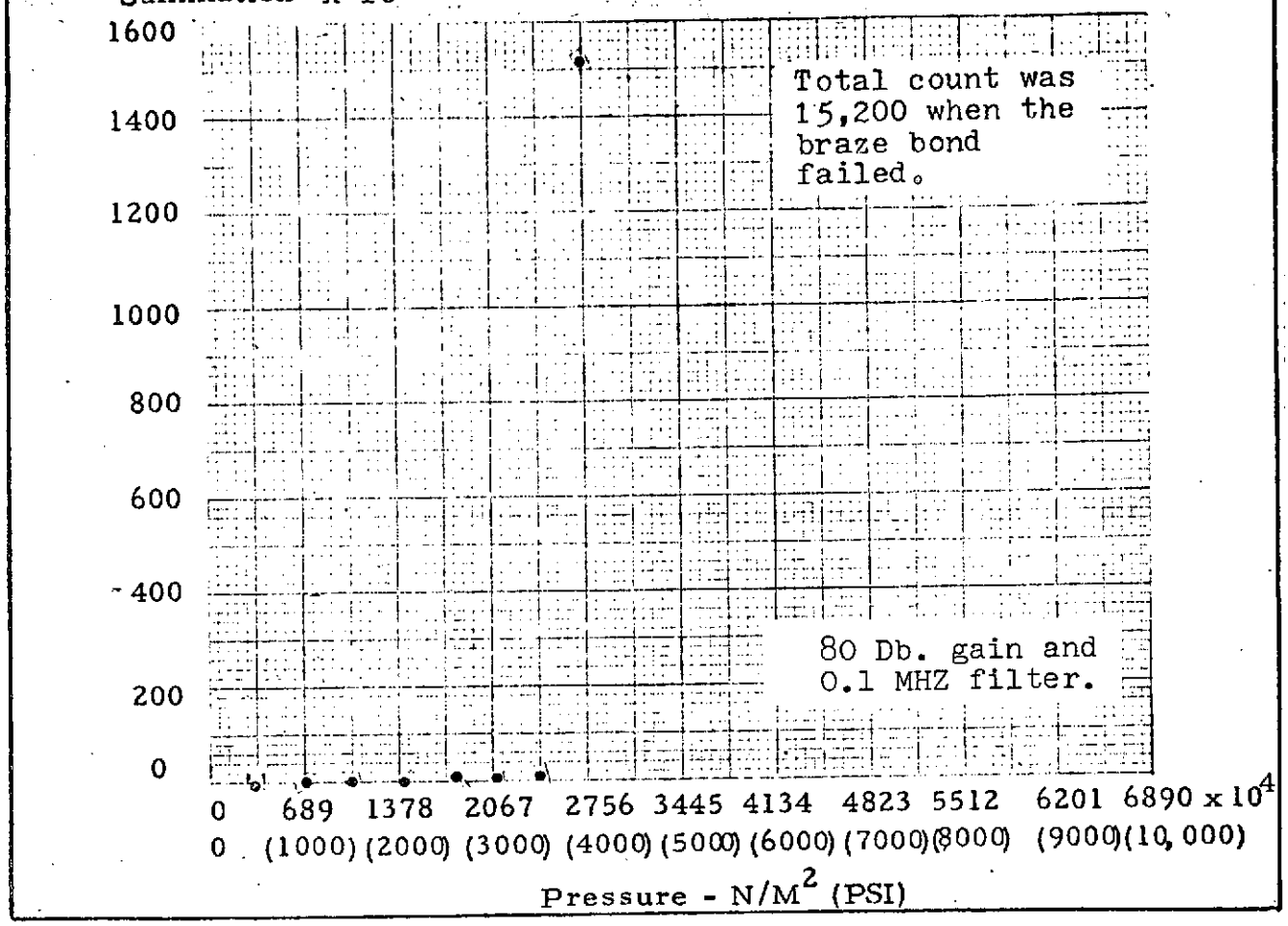


Full bond showing no failure. Note small voids in the braze layer. Magnification 50X.

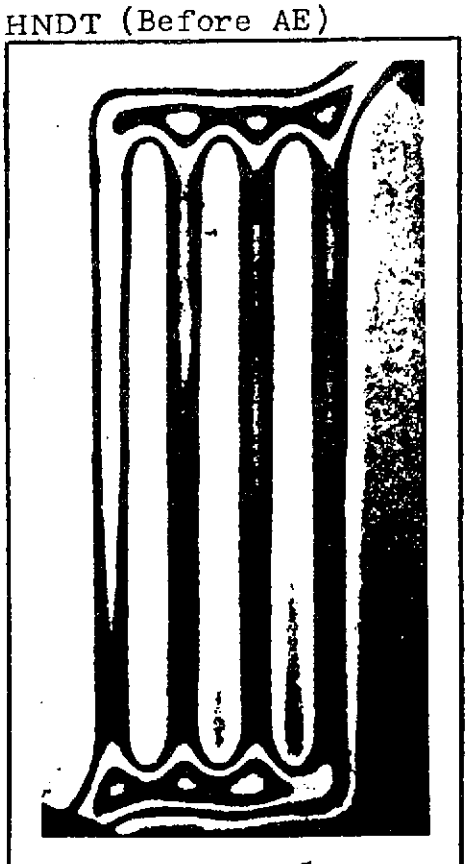
Bond failure section illustrates separation occurred through the braze alloy. Magnification 50X.

FIGURE A-13

Panel No. B-03

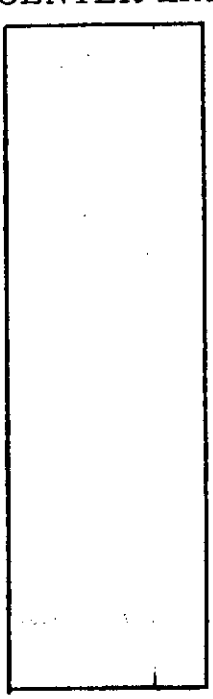


HNDT (Before AE)

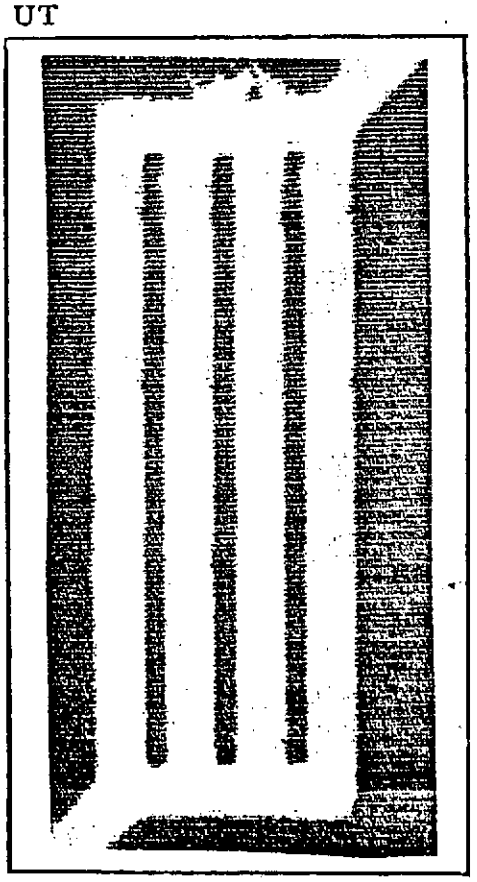


Press. 6.9 x 10^5 N/M^2
(100 PSI)

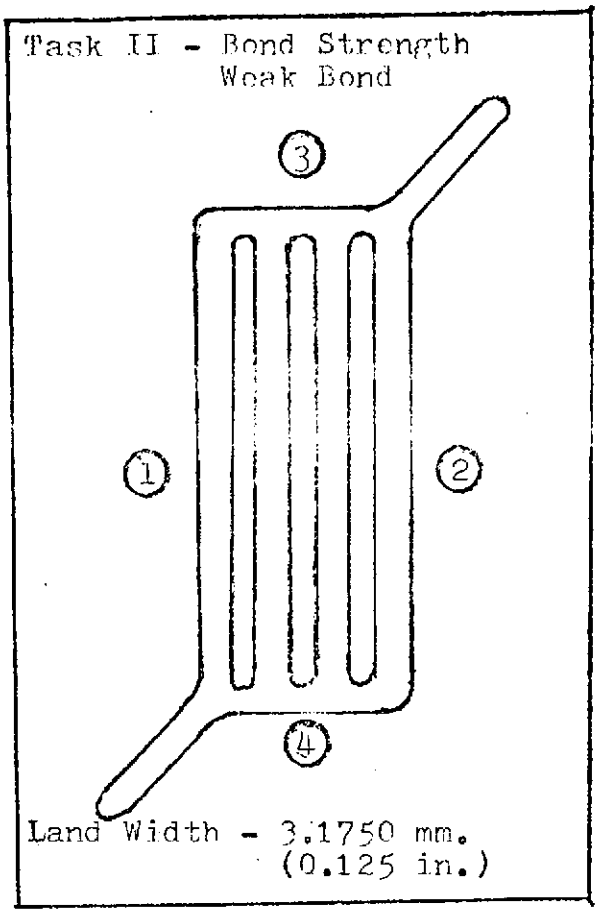
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-07



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.6497	0.2618
②	6.6599	0.2622
③	6.6650	0.2624
④	6.6878	0.2633

COVERPLATE

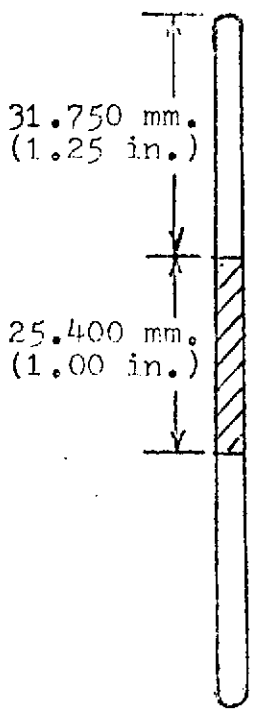
MATERIAL: 304L Stainless Steel

THICKNESS:	MM.	INCHES
①	1.2217	0.0481
②	1.2217	0.0481
③	1.2243	0.0482
④	1.2217	0.0481

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 3.66×10^7 N/m^2 (5,300 psi). Coverplate actually buckled without bond failure.

CENTER LAND DEFECT

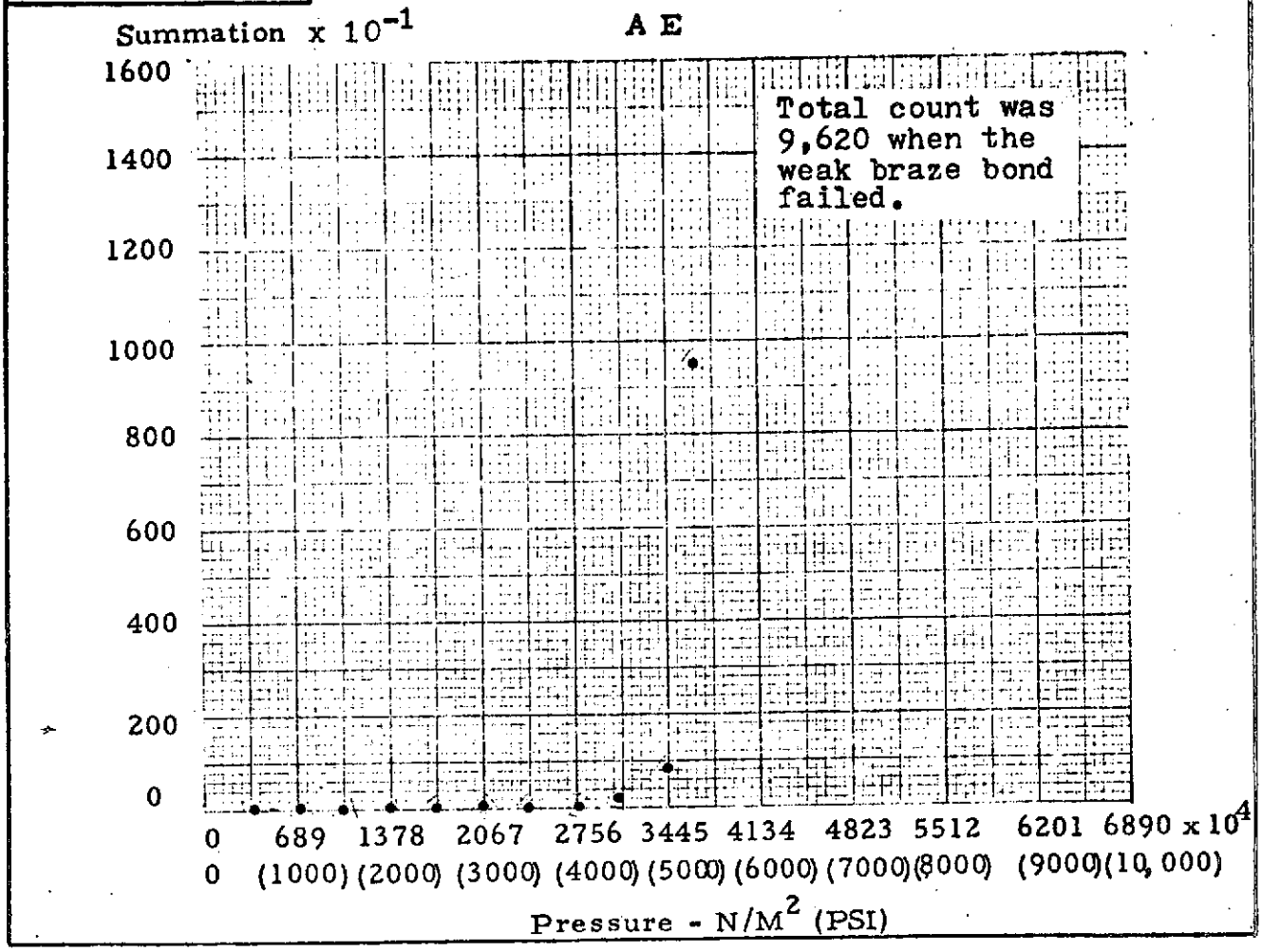


METALLOGRAPHIC ANALYSIS:

This panel was not sectioned for metallurgical examination. The process used to produce the weak bond actually resulted in a full braze bond. See Panel B-10, Figure A-15, for results of the process selected.

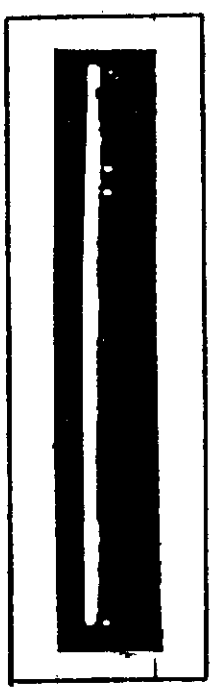
FIGURE A-14

Panel No. B-07

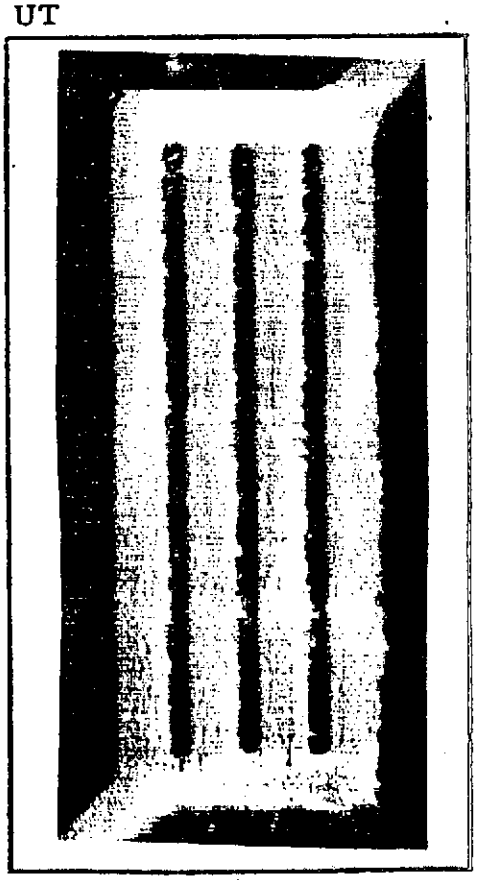


HNDT

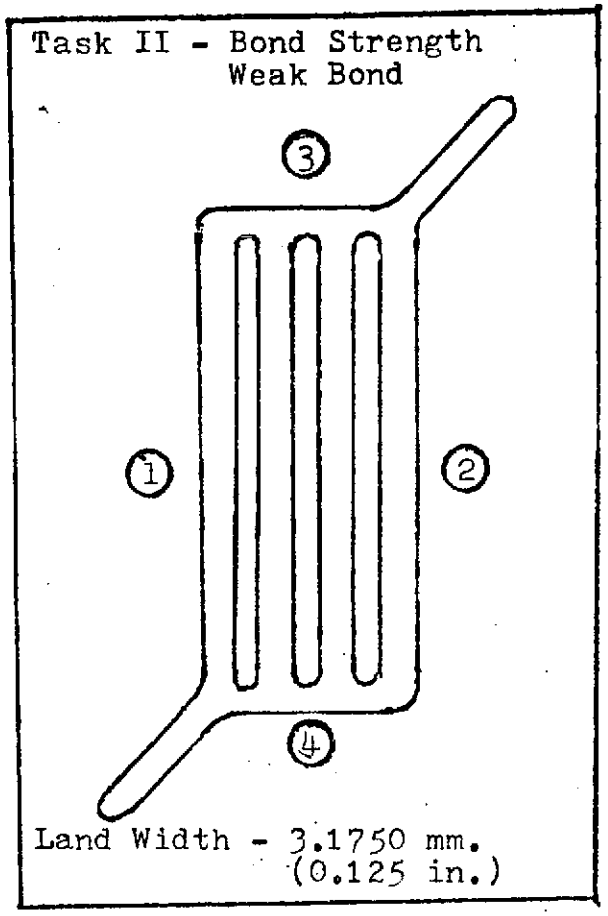
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-10



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.5532	0.2580
②	6.5227	0.2568
③	6.6675	0.2625
④	6.6192	0.2606

COVERPLATE

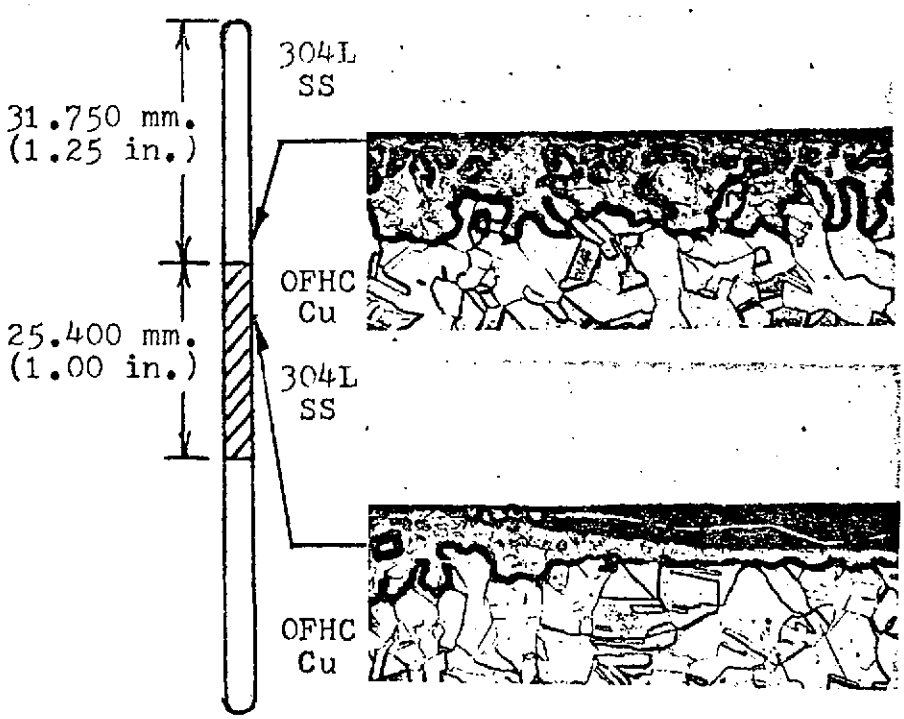
MATERIAL: 304L Stainless Steel

THICKNESS:	MM.	INCHES
①	1.2243	0.0482
②	1.2268	0.0483
③	1.2268	0.0483
④	1.2268	0.0483

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 1.28×10^7 N/m^2 (1,850 psi).

CENTER LAND DEFECT METALLOGRAPHIC ANALYSIS:

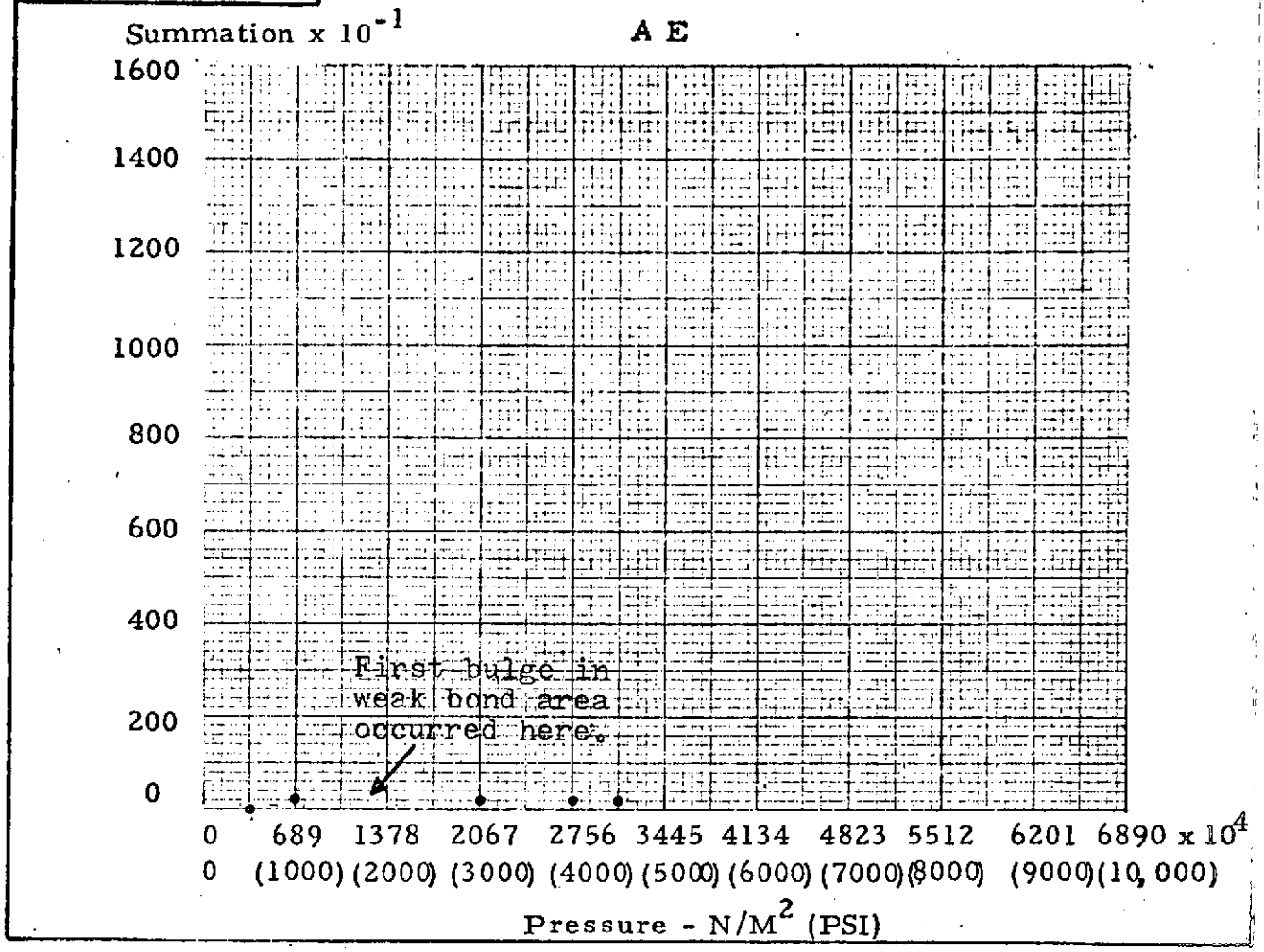


Section showing full bond adjacent to the planned weak bond. Magnification 50X.

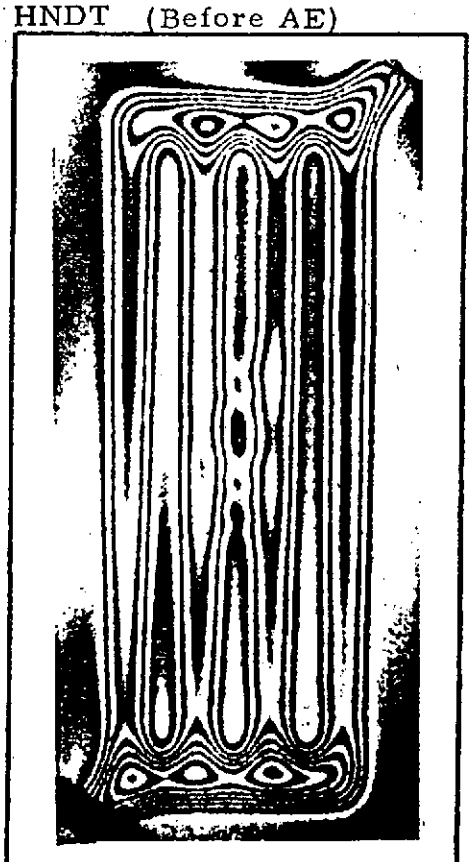
Section from the planned weak bond area showing regions of poor braze wetting of the Stainless coverplate. Magnification 50X.

FIGURE A-15

Panel No. B-10

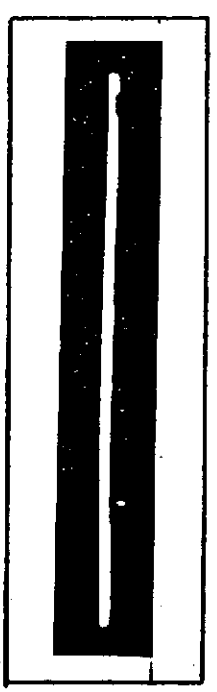


HNDT (Before AE)

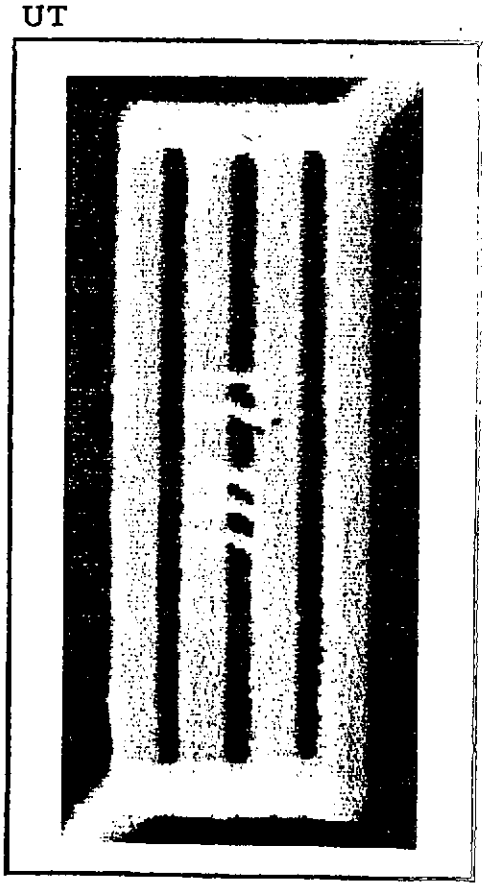


Press. - 20.7 x 10^5 N/M^2
(300 PSI)

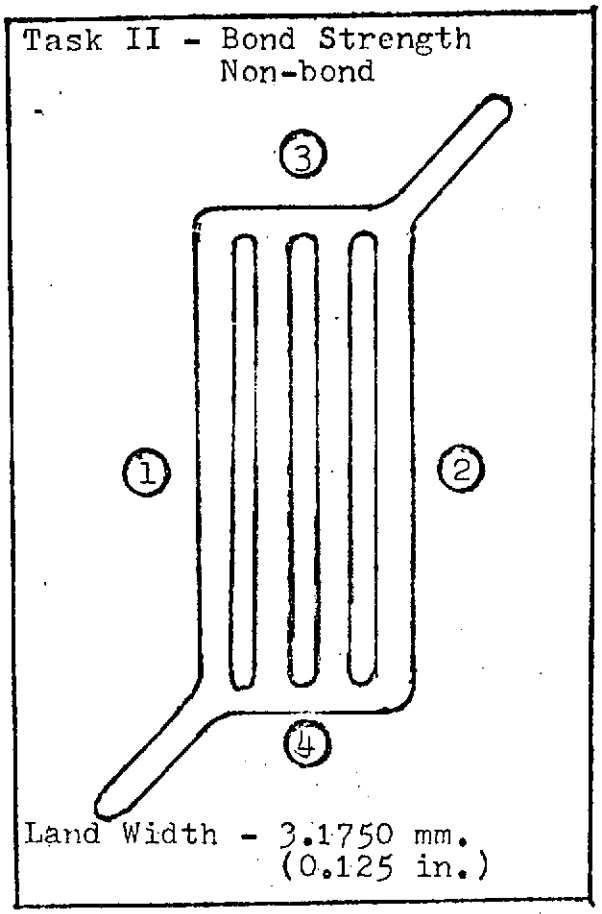
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-05



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.6523	0.2619
②	6.7183	0.2645
③	6.6396	0.2614
④	6.6777	0.2629

COVERPLATE

MATERIAL: 304L Stainless Steel

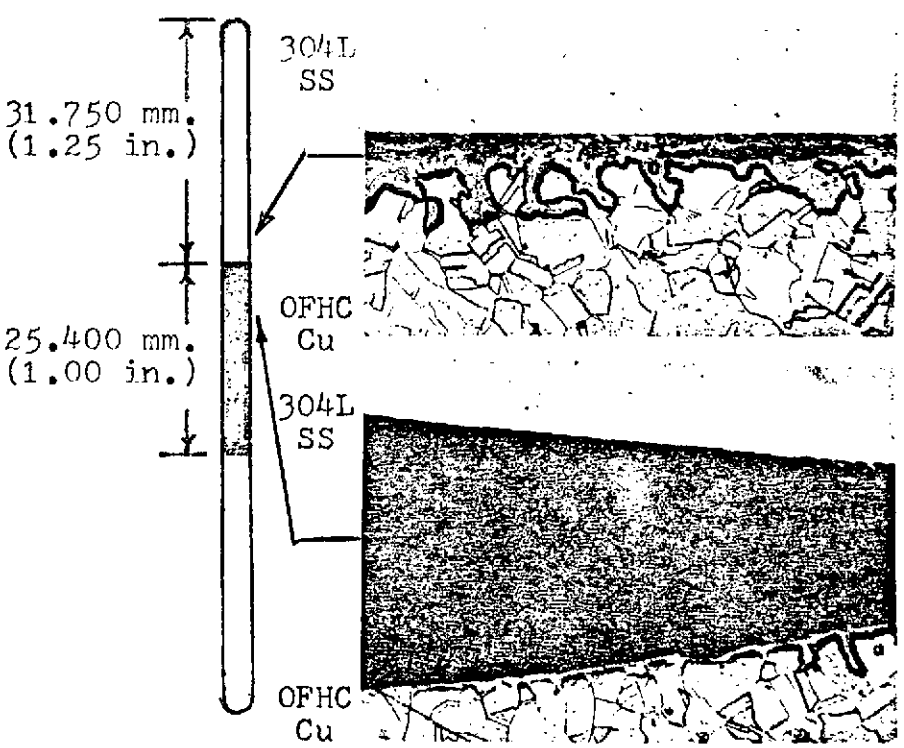
THICKNESS:	MM.	INCHES
①	1.2268	0.0483
②	1.2268	0.0483
③	1.2243	0.0482
④	1.2268	0.0483

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 0.83×10^7 N/m^2 (1,200 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

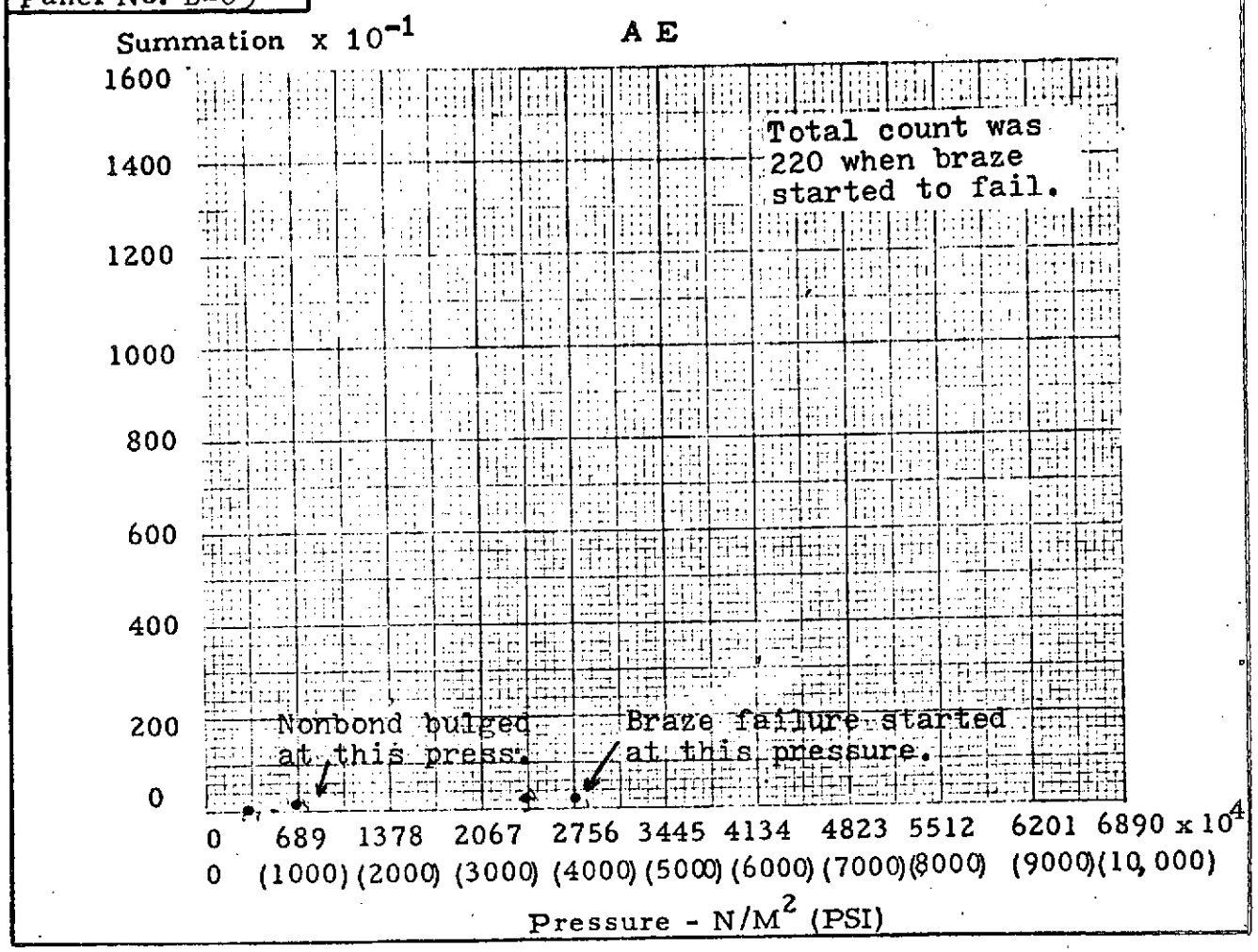


Section from full bond adjacent to the planned non-bond. Some braze failure was initiated. Magnification 50X.

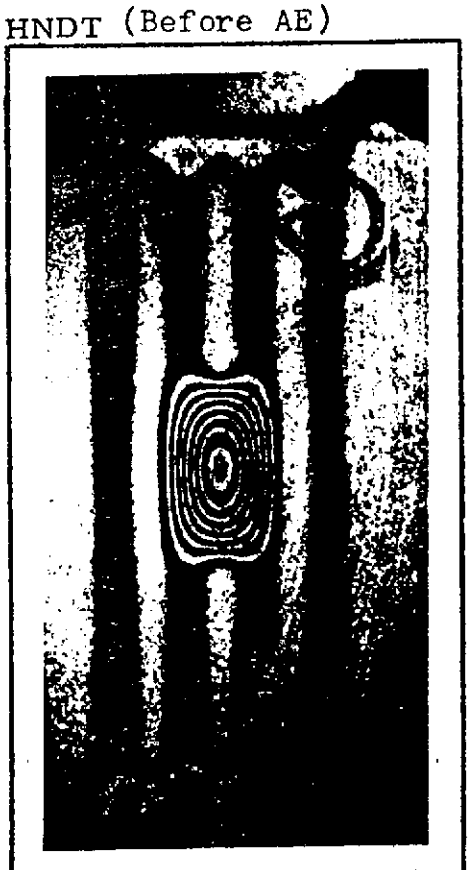
Illustration of separation which occurred in the planned nonbond. Magnification 50X.

FIGURE A-16

Panel No. B-05



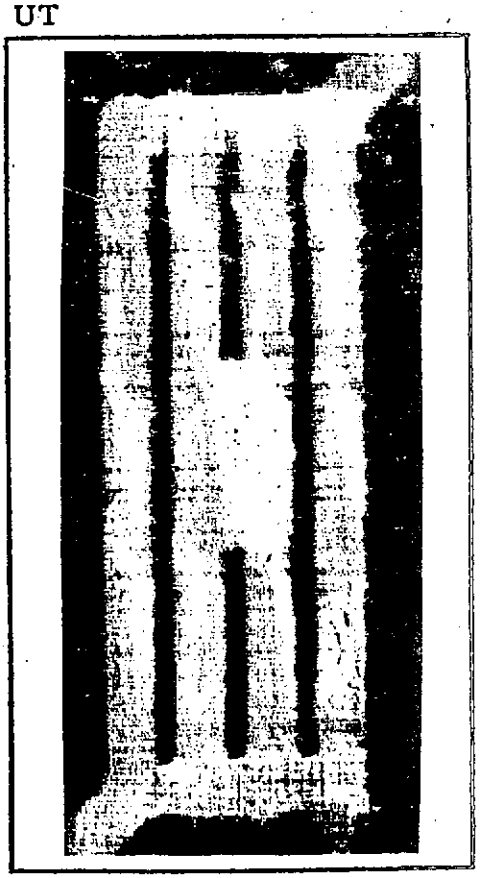
HNDT (Before AE)



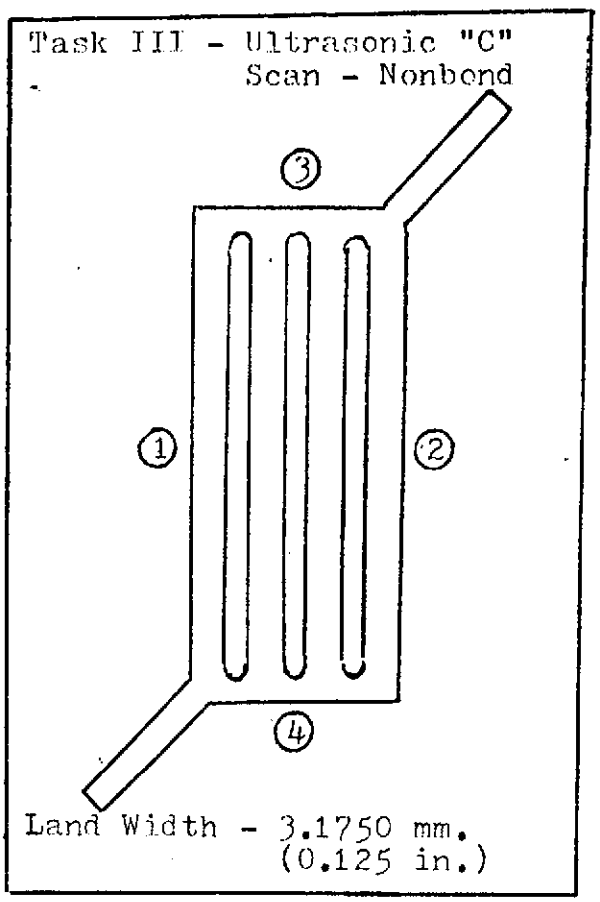
Press. 3.45×10^5 N/M^2 (50 PSI)

AE FLAW LOCATOR CENTER LAND

UT



ELECTROFORMED PANEL NO. N-14



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.003 in (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.2789	0.2472
②	6.2763	0.2471
③	6.2738	0.2470
④	6.2713	0.2469

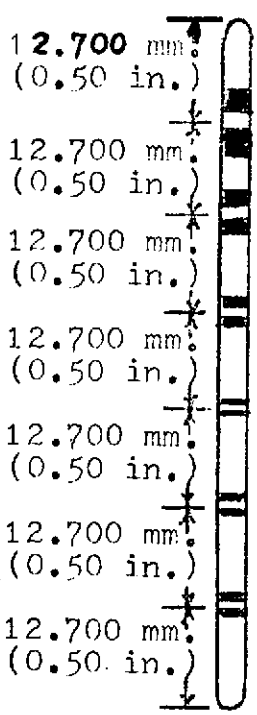
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.4978	0.0196
②	0.5055	0.0199
③	0.5105	0.0201
④	0.5359	0.0211

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable



Slot	3.1496 mm.	(0.124 in.)
Space	3.2004 mm.	(0.126 in.)
Slot	3.1750 mm.	(0.125 in.)
Slot	1.6256 mm.	(0.064 in.)
Space	1.6256 mm.	(0.064 in.)
Slot	1.6510 mm.	(0.065 in.)
Slot	0.7620 mm.	(0.030 in.)
Space	0.8890 mm.	(0.035 in.)
Slot	0.7620 mm.	(0.030 in.)
Slot	0.1016 mm.	(0.004 in.)
Space	0.1524 mm.	(0.006 in.)
Slot	0.1016 mm.	(0.004 in.)
Slot	0.2032 mm.	(0.008 in.)
Space	0.7112 mm.	(0.028 in.)
Slot	0.2032 mm.	(0.008 in.)
Slot	0.3810 mm.	(0.015 in.)
Space	0.3302 mm.	(0.013 in.)
Slot	0.4064 mm.	(0.016 in.)

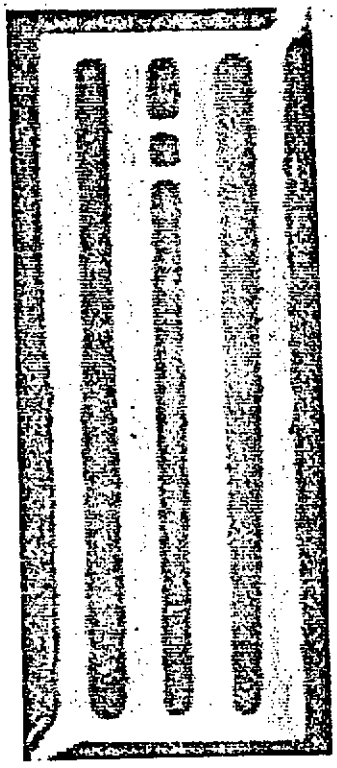
All slots were produced by electric discharge machining to a depth of 0.254 mm. (0.010 in.)

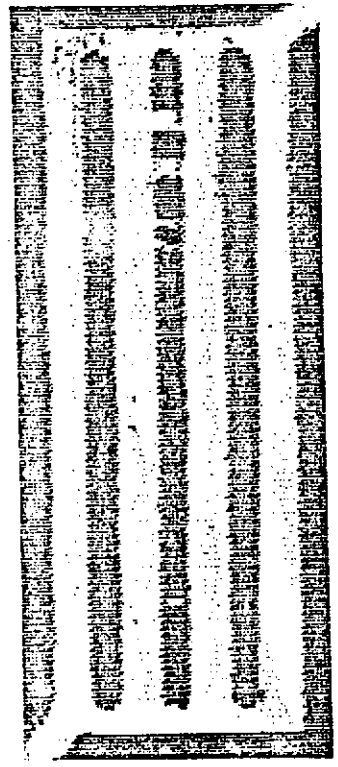
FIGURE B-1

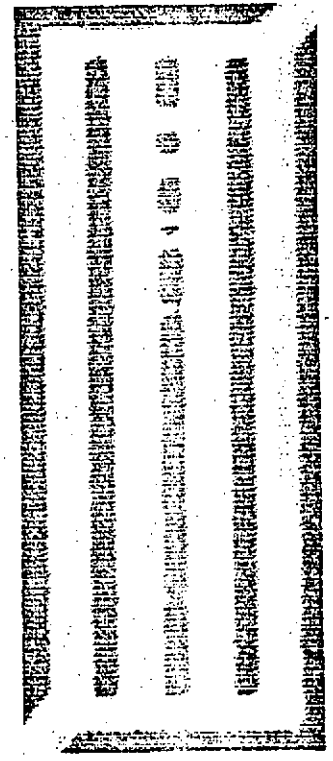
ULTRASONIC "C" SCAN STANDARD

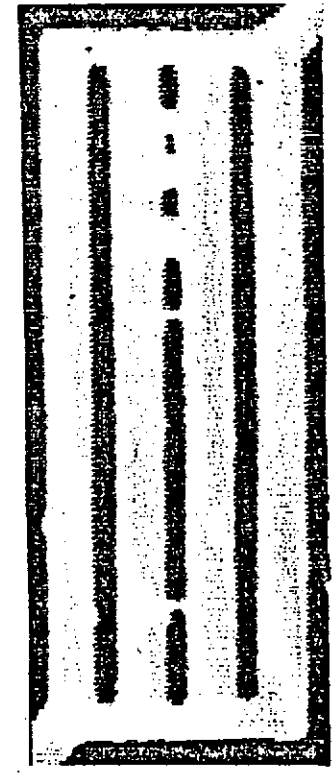
PANEL N-14, COVERPLATE THICKNESS 0.5080 mm. (0.020 in.)

PULSE ECHO METHOD	PULSE ECHO METHOD	THRU-TRANSMISSION METHOD	REFLECTOR METHOD
50 W Pulser Receiver	HRL Pulser Receiver	10 N Pulser Receiver	10 N Pulser Receiver
20 MHZ Medium Focused Transducer	20 MHZ Medium Focused Transducer	10 MHZ Medium Focused Transducers	10 MHZ Medium Focused Transducer

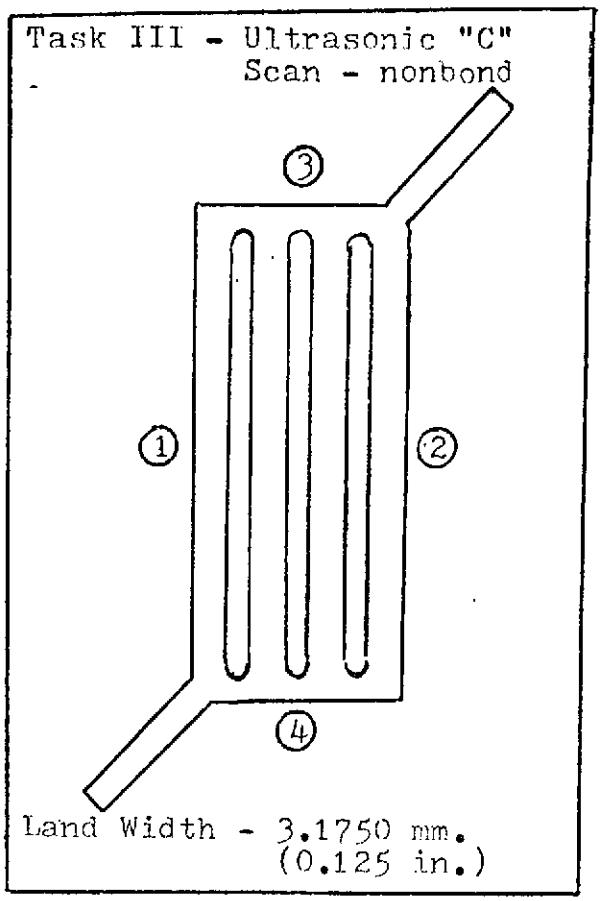








ELECTROFORMED PANEL NO. N-15



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.007 in. (0.1778 mm.)

THICKNESS:	MM.	INCHES
①	6.2789	0.2472
②	6.2789	0.2472
③	6.2611	0.2465
④	6.2611	0.2465

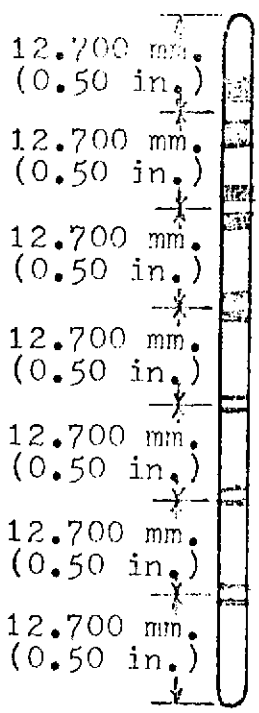
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.0185	0.0401
②	1.0084	0.0397
③	1.0135	0.0399
④	0.9728	0.0383

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable



Slot	3.1750 mm.	(0.125 in.)
Space	3.2004 mm.	(0.126 in.)
Slot	3.1496 mm.	(0.124 in.)
Slot	1.6256 mm.	(0.064 in.)
Space	1.5748 mm.	(0.062 in.)
Slot	1.6256 mm.	(0.064 in.)
Slot	0.7874 mm.	(0.031 in.)
Space	0.8128 mm.	(0.032 in.)
Slot	0.7874 mm.	(0.031 in.)
Slot	0.1016 mm.	(0.004 in.)
Space	0.1524 mm.	(0.006 in.)
Slot	0.1016 mm.	(0.004 in.)
Slot	0.2286 mm.	(0.009 in.)
Space	0.3302 mm.	(0.013 in.)
Slot	0.2032 mm.	(0.008 in.)
Slot	0.4064 mm.	(0.016 in.)
Space	0.3810 mm.	(0.015 in.)
Slot	0.4064 mm.	(0.016 in.)

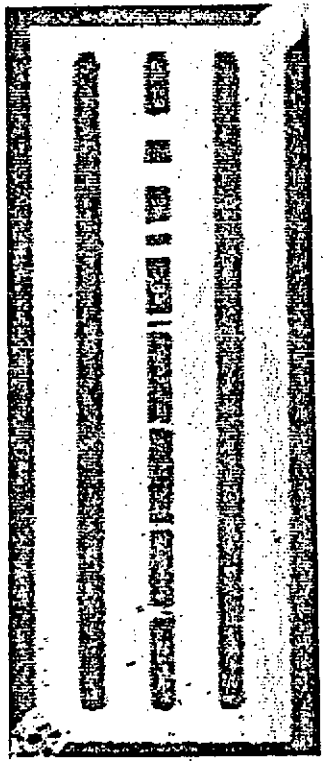
All slots were produced by electric discharge machining to a depth of 0.254 mm. (0.010 in.)

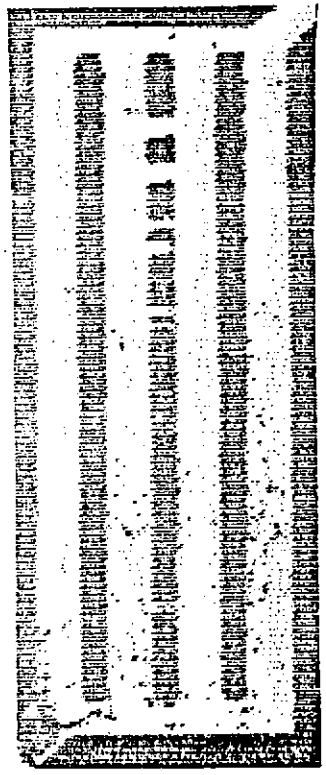
FIGURE B-2

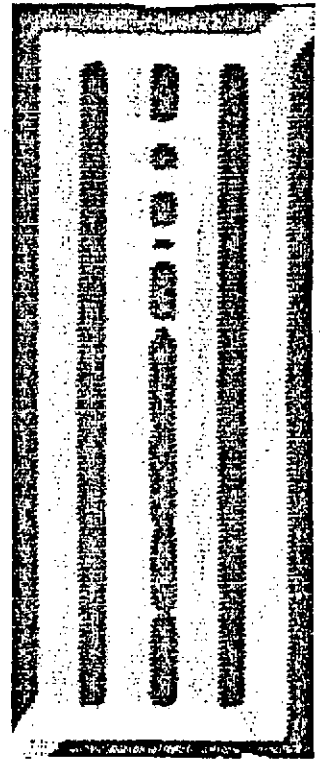
ULTRASONIC "C" SCAN STANDARD

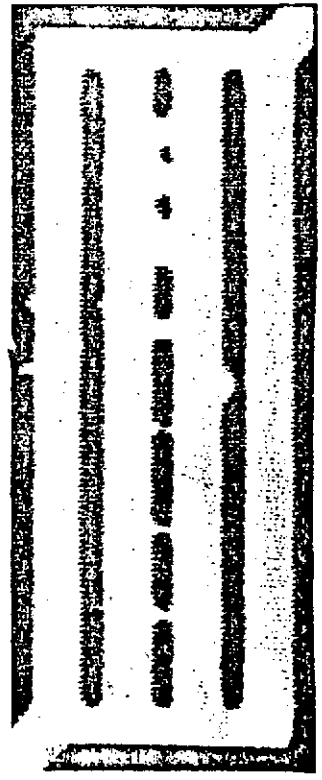
PANEL N-15, COVERPLATE THICKNESS 1.0160 mm. (0.040 in.)

PULSE ECHO METHOD	PULSE ECHO METHOD	THRU-TRANSMISSION METHOD	REFLECTOR METHOD
50 W Pulser Receiver	HRL Pulser Receiver	10 N Pulser Receiver	10 N Pulser Receiver
20 MHZ Medium Focused Transducer	20 MHZ Medium Focused Transducer	10 MHZ Medium Focused Transducers	10 MHZ Medium Focused Transducer

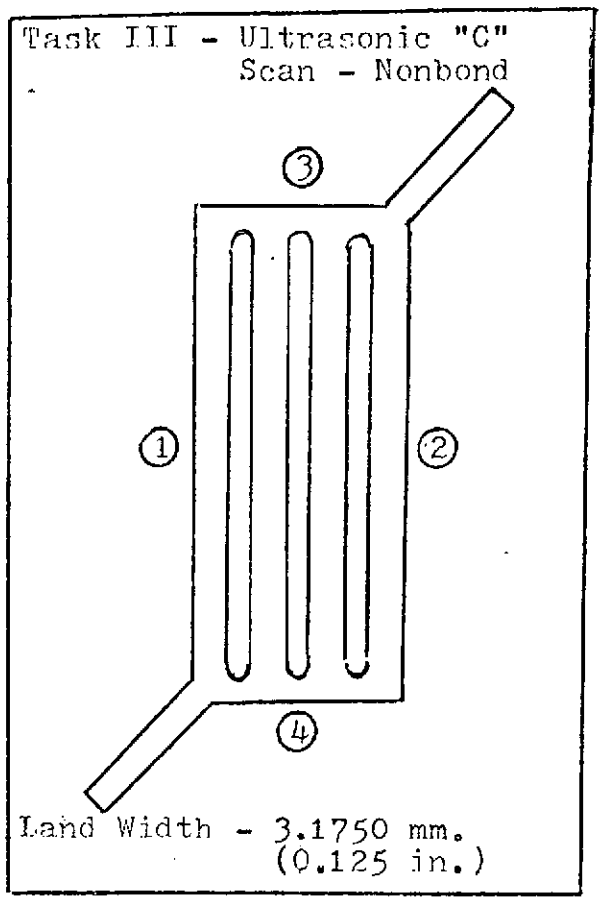








ELECTROFORMED PANEL NO. N-16



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.004 in. (0.1016 mm.)

THICKNESS:	MM.	INCHES
①	6.2890	0.2476
②	6.2611	0.2465
③	6.2484	0.2460
④	6.2560	0.2463

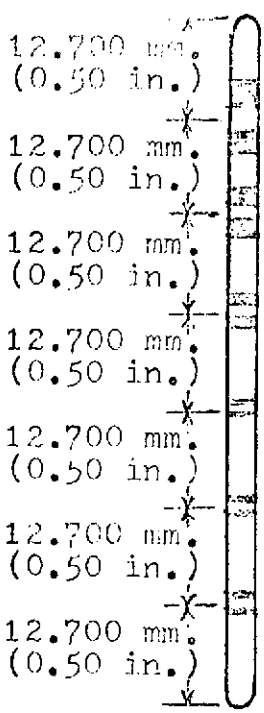
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4529	0.0572
②	1.4884	0.0586
③	1.5469	0.0609
④	1.4910	0.0587

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable



Slot	3.1496 mm.	(0.124 in.)	
Space	3.2004 mm.	(0.126 in.)	
Slot	3.1750 mm.	(0.125 in.)	
Slot	1.6256 mm.	(0.064 in.)	
Space	1.6256 mm.	(0.064 in.)	
Slot	1.6256 mm.	(0.064 in.)	
Slot	0.7620 mm.	(0.030 in.)	
Space	0.8636 mm.	(0.034 in.)	
Slot	0.7620 mm.	(0.030 in.)	
Slot	0.1016 mm.	(0.004 in.)	
Space	0.1524 mm.	(0.006 in.)	
Slot	0.1016 mm.	(0.004 in.)	
Slot	0.1778 mm.	(0.007 in.)	
Space	0.1778 mm.	(0.007 in.)	
Slot	0.2032 mm.	(0.008 in.)	
Slot	0.3810 mm.	(0.015 in.)	
Space	0.3302 mm.	(0.013 in.)	
Slot	0.4064 mm.	(0.016 in.)	

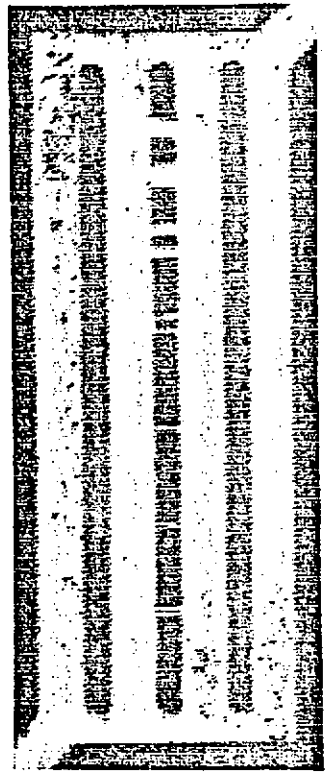
All slots were produced by electric discharge machining to a depth of 0.254 mm. (0.010 in.)

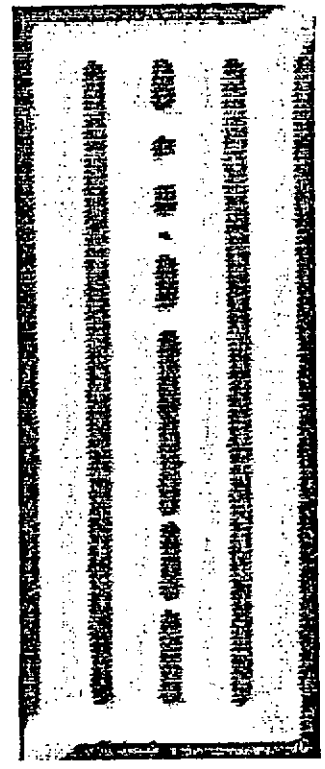
FIGURE B-3

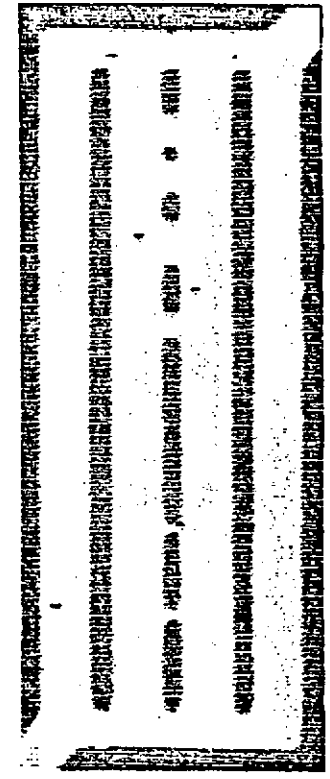
ULTRASONIC "C" SCAN STANDARD

PANEL N-16, COVERPLATE THICKNESS 1.5240 mm. (0.060 in.)

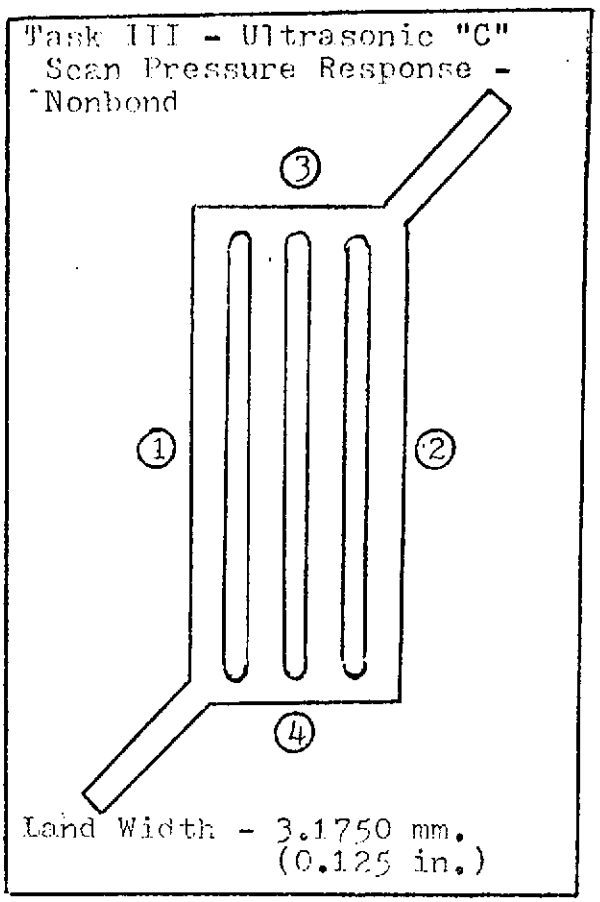
PULSED ECHO METHOD	PULSE ECHO METHOD	THRU-TRANSMISSION METHOD	REFLECTOR METHOD
50 W Pulser Receiver	HRL Pulser Receiver	10 N Pulser Receiver	10 N Pulser Receiver
20 MHZ Medium Focused Transducer	20 MHZ Medium Focused Transducer	10 MHZ Medium Focused Transducers	10 MHZ Medium Focused Transducer







ELECTROFORMED PANEL NO. N-17



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.008 in. (0.2032 mm.)

THICKNESS:	MM.	INCHES
①	6.2499	0.2459
②	6.2357	0.2455
③	6.1900	0.2437
④	6.2230	0.2450

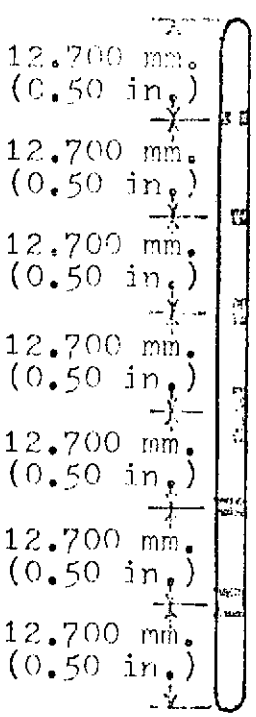
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.5512	0.0217
②	0.5232	0.0206
③	0.5791	0.0228
④	0.5385	0.0212

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable



All of the below planned defects are in intimate contact with the electroformed coverplate.

2 areas 1.5748 mm. long x 1.2700 mm. wide
(0.062 in.) (0.050 in.)

Area 1.5748 mm. long x ½ land width
(0.062 in.)

Area 3.1750 mm. long x ½ land width
(0.125 in.)

Area 6.3500 mm. long x ½ land width
(0.250 in.)

Area 1.5748 mm. long x land width
(0.062 in.)

Area 3.1750 mm. long x land width
(0.125 in.)

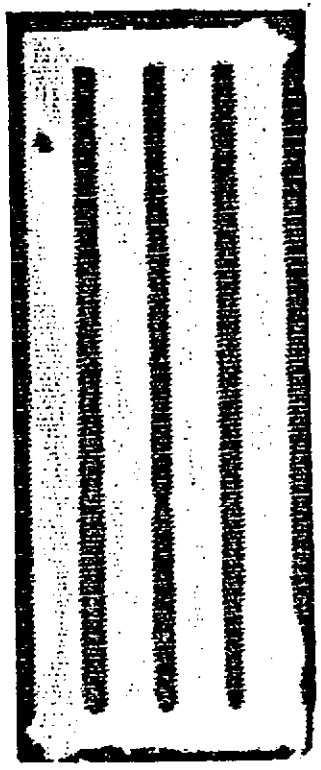
FIGURE B-4

ULTRASONIC PRESSURE STUDY - PANEL N-17

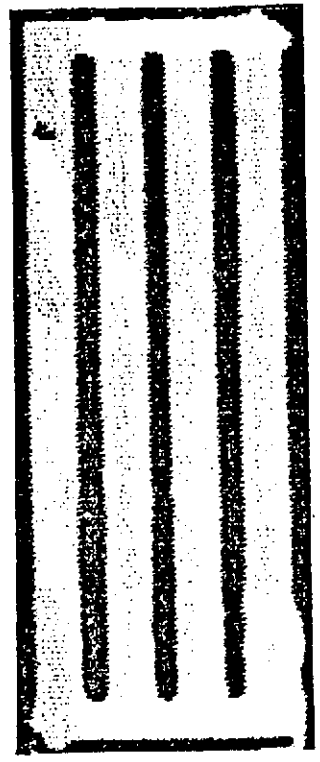
COVERPLATE THICKNESS 0.5334 mm. (0.021 in.)

PULSE ECHO METHOD

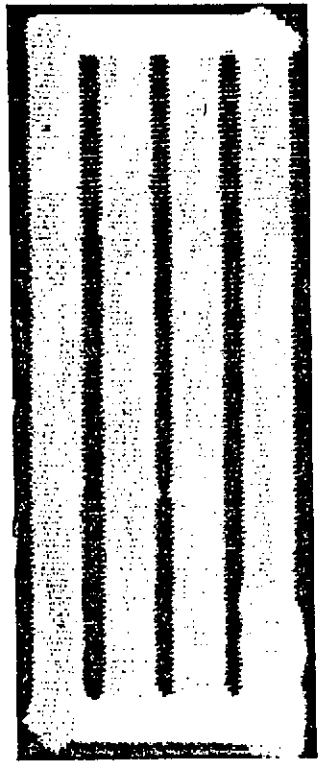
2.07 MN/m.^{2}
(300 PSI)



3.11 MN/m.^{2}
(450 PSI)

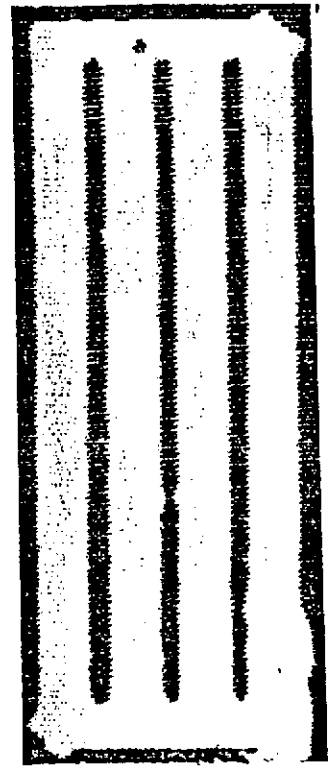


3.11 MN/m.^{2}
(450 PSI)



Low Gain

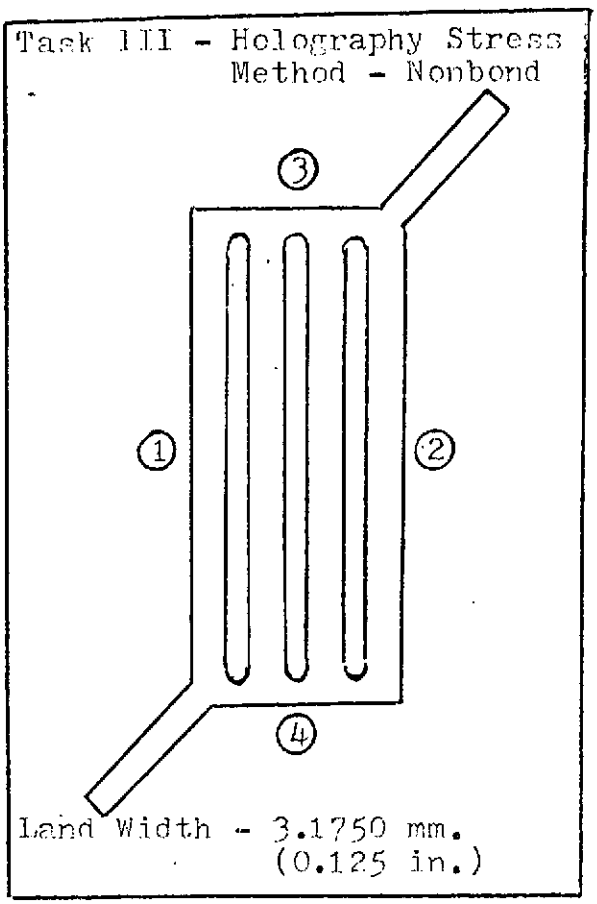
0 MN/m.^{2}
(0 PSI)



Low Gain

Only the long defect (with respect to land edge) showed response to pressure.

ELECTROFORMED PANEL NO. N-25



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.2509	0.2461
②	6.2509	0.2461
③	6.1976	0.2440
④	6.2509	0.2461

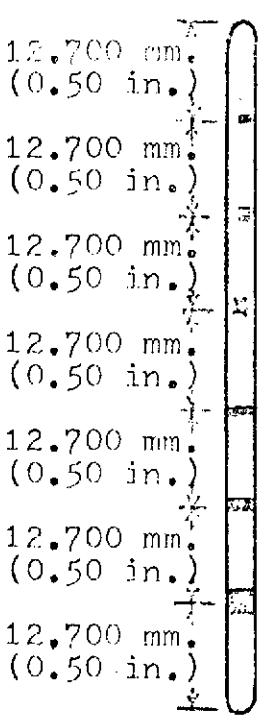
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4249	0.0561
②	1.4732	0.0580
③	1.5189	0.0598
④	1.5418	0.0607

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable



Slot 0.7874 mm. long x ½ land width (0.031 in.)

Slot 1.5748 mm. long x ½ land width (0.062 in.)

Hole 3.1750 mm. long (0.125 in.) x 1.5748 mm. (0.062 in.) in land center

Slot 0.7874 mm. long (0.031 in.) x land width

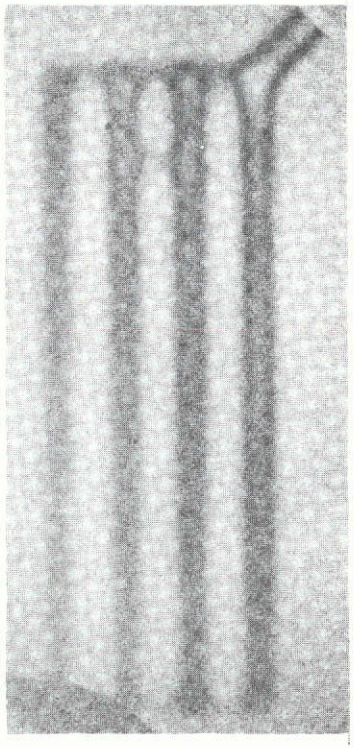
Slot 1.5748 mm. long (0.062 in.) x land width

Slot 3.1750 mm. long (0.125 in.) x land width

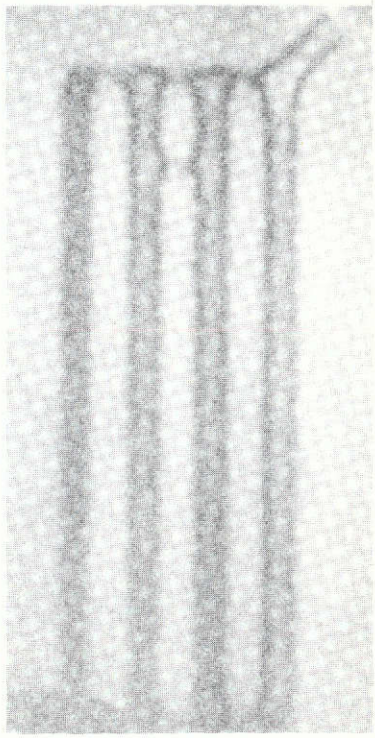
All slots were produced by electric discharge machining to a depth of 0.254 mm. (0.010 in.)

FIGURE B-5

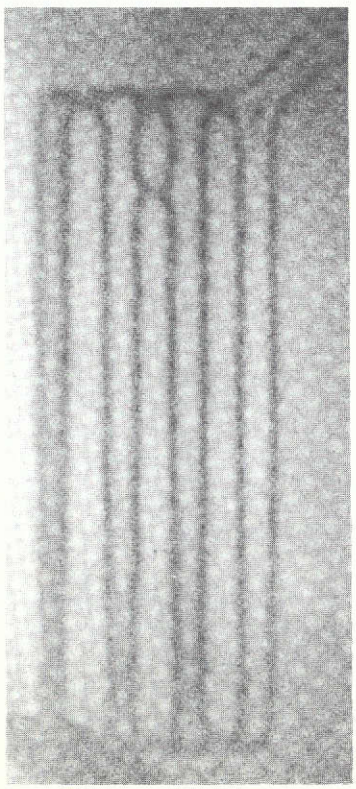
TASK III - HOLOGRAPHIC STANDARD PRESSURE STUDY: N-25
.059" ELECTROFORM NICKEL COVERPLATE



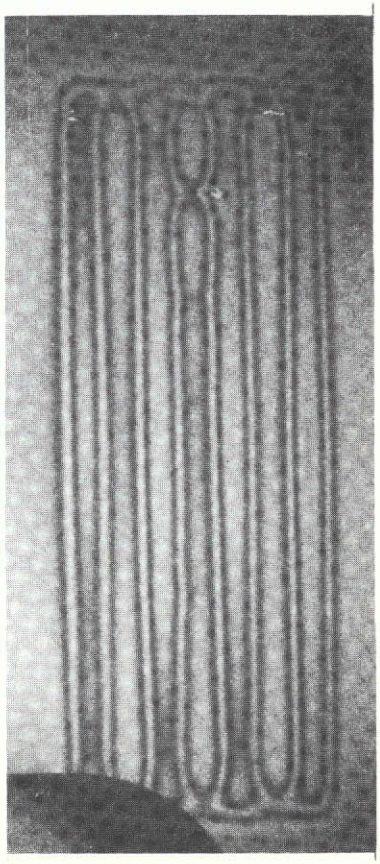
8.62×10^5 N/M^2
(125 PSI)



12.07×10^5 N/M^2
(175 PSI)

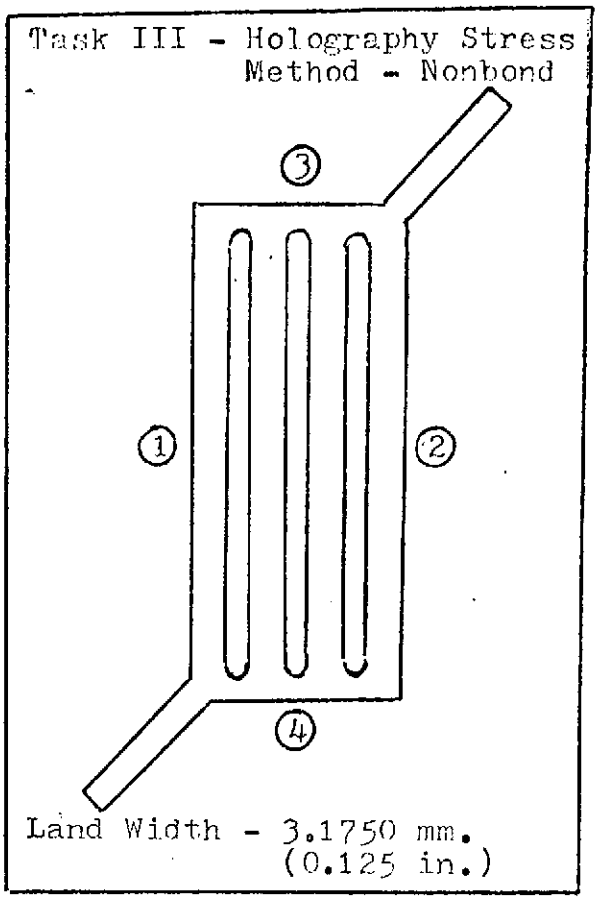


15.5×10^5 N/M^2
(225 PSI)



31.0×10^5 N/M^2
(450 PSI)

ELECTROFORMED PANEL NO. N-26



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.1773	0.2432
②	6.1722	0.2430
③	6.1671	0.2428
④	6.1773	0.2432

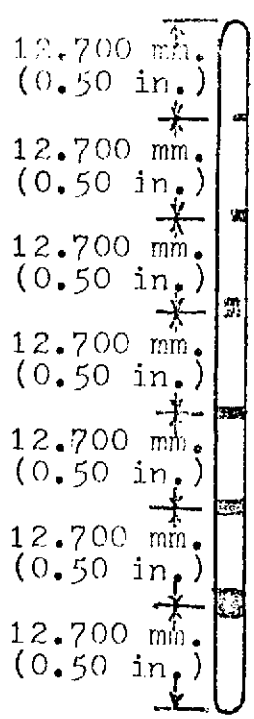
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.5080	0.0200
②	0.5385	0.0212
③	0.5080	0.0200
④	0.5334	0.0210

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable



Slot 0.7874 mm. long x $\frac{1}{8}$ land width
(0.031 in.)

Slot 1.5748 mm. long x $\frac{1}{2}$ land width
(0.062 in.)

Hole 3.1750 mm. long x 1.5748 mm. in land center
(0.125 in.) (0.062 in.)

Slot 0.7874 mm. long x land width
(0.031 in.)

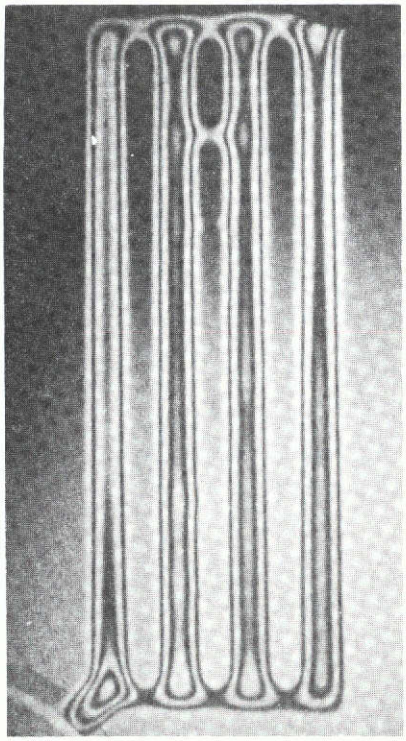
Slot 1.5748 mm. long x land width
(0.062 in.)

Slot 3.1750 mm. long x land width
(0.125 in.)

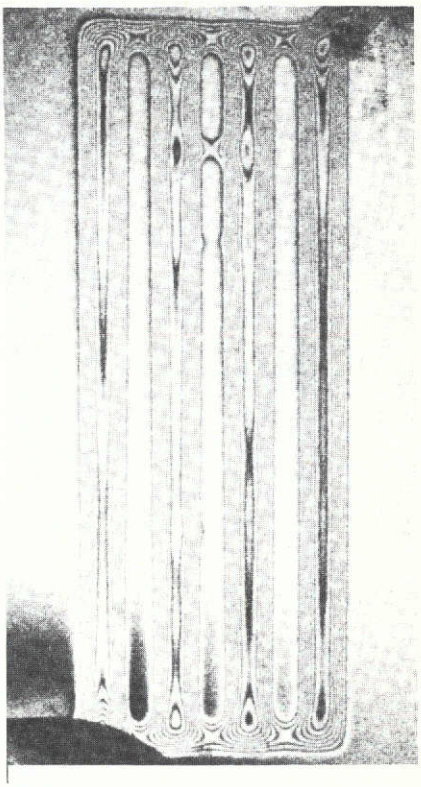
All slots were produced by electric discharge machining to a depth of 0.254 mm. (0.010 in.)

FIGURE B-6

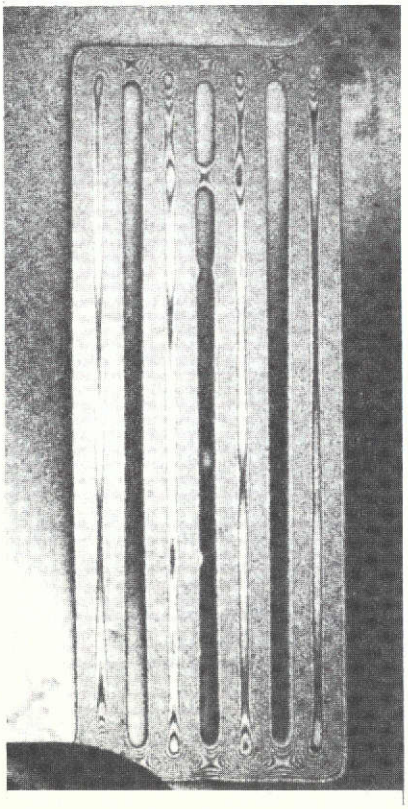
TASK III - HOLOGRAPHIC STANDARD PRESSURE STUDY: N-26
.020" ELECTROFORM NICKEL COVERPLATE



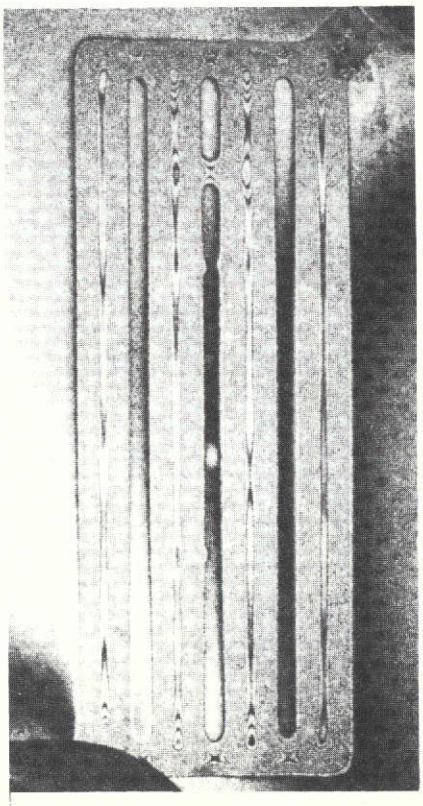
3.45×10^5 N/M^2
(50 PSI)



17.25×10^5 N/M^2
(250 PSI)

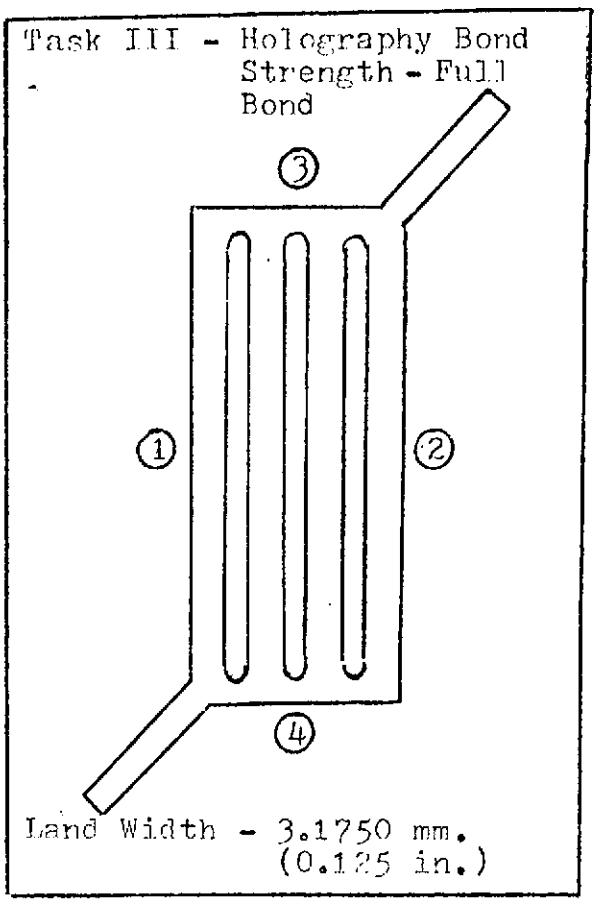


24.2×10^5 N/M^2
(350 PSI)



31.0×10^5 N/M^2
(450 PSI)

ELECTROFORMED PANEL NO. N-12



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.001 in. (0.0254 mm.)

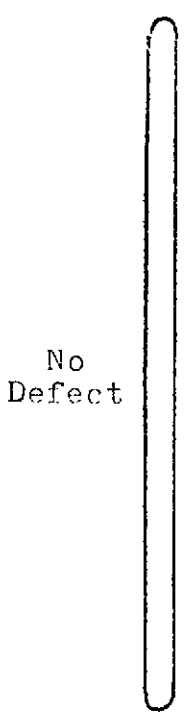
THICKNESS:	MM.	INCHES
①	6.2408	0.2457
②	6.2306	0.2453
③	6.2154	0.2447
④	6.2230	0.2450

COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4808	0.0583
②	1.4402	0.0567
③	1.4681	0.0578
④	1.4681	0.0578

CENTER LAND DEFECT

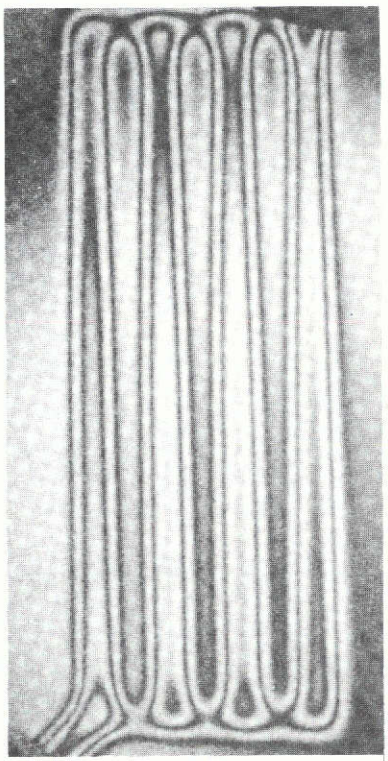


METALLOGRAPHIC ANALYSIS: Not Applicable

FIGURE B-7

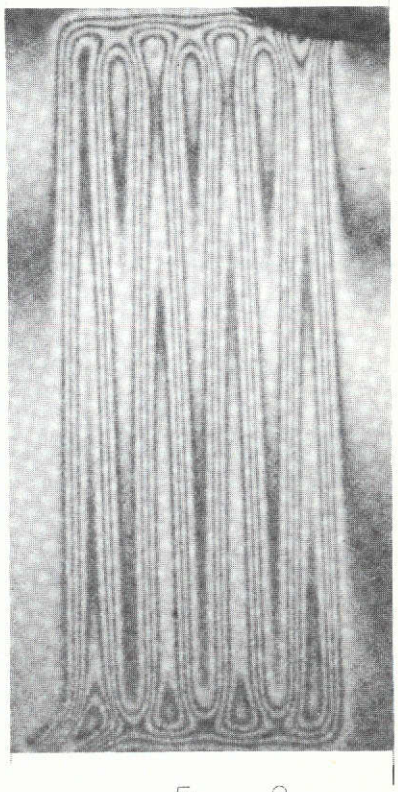
TASK III - HOLOGRAPHY BOND STRENGTH STUDY

N-12 Full



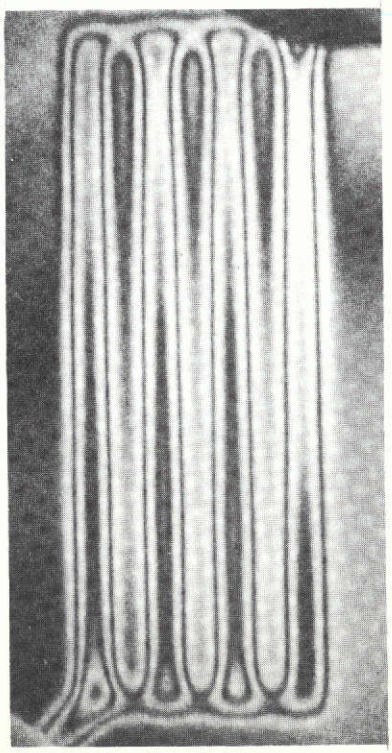
31.0×10^5 N/M^2
(450 PSI)

N-12 Full



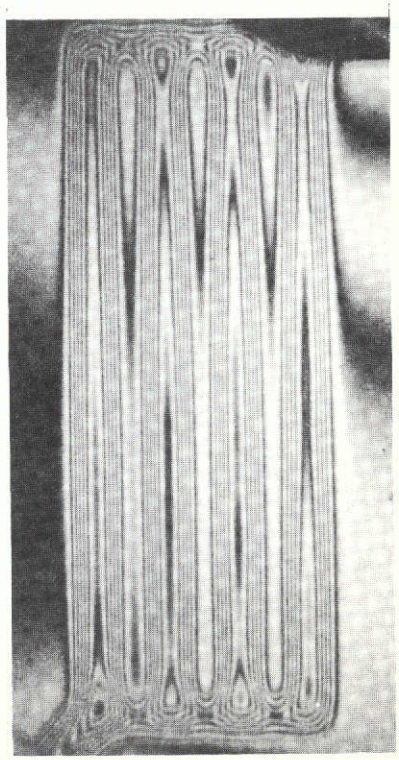
63.8×10^5 N/M^2
(925 PSI)

N-18 Weak



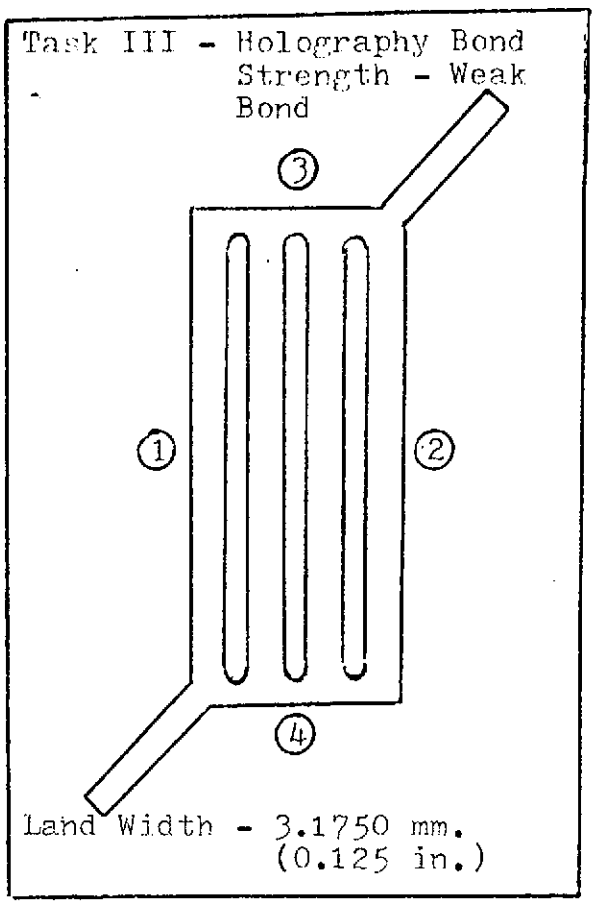
37.9×10^5 N/M^2
(550 PSI)

N-18 Weak



96.6×10^5 N/M^2
(1400 PSI)

ELECTROFORMED PANEL NO. N-18



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.2713	0.2469
②	6.2636	0.2466
③	6.2916	0.2477
④	6.2484	0.2460

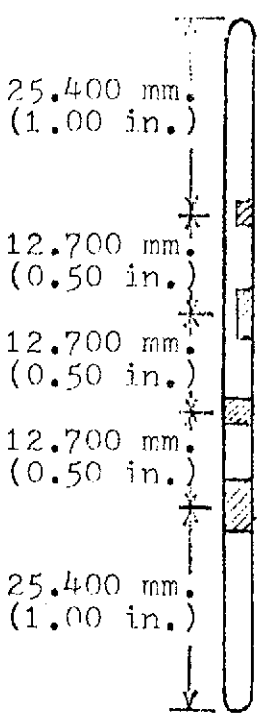
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4910	0.0587
②	1.4910	0.0587
③	1.4884	0.0586
④	1.4859	0.0585

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable



Defect 3.1750 mm. wide x ½ land width (0.125 in.)

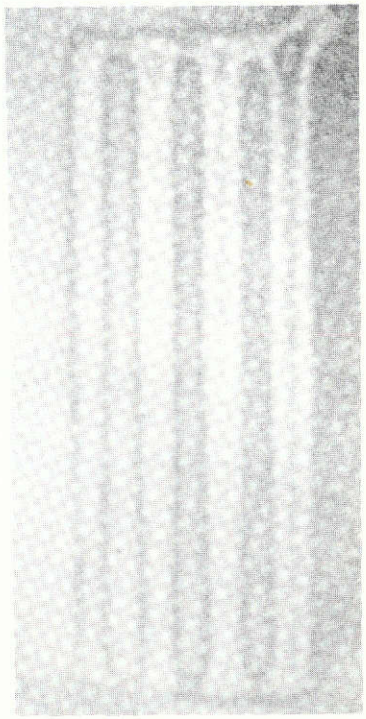
Defect 6.3500 mm. wide x ½ land width (0.250 in.)

Defect 3.1750 mm. wide x land width (0.125 in.)

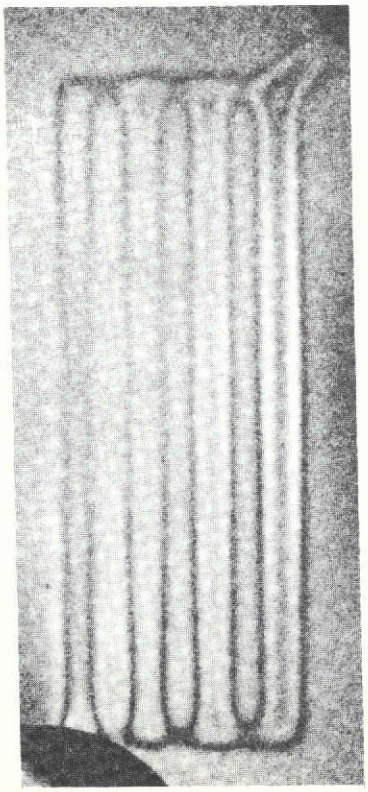
Defect 6.3500 mm. wide x land width (0.250 in.)

FIGURE B-8

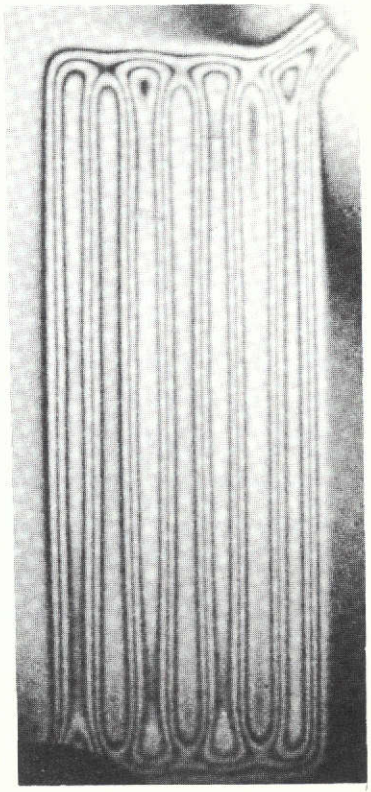
12.1×10^5 N/M^2
(175 PSI)



15.5×10^5 N/M^2
(225 PSI)

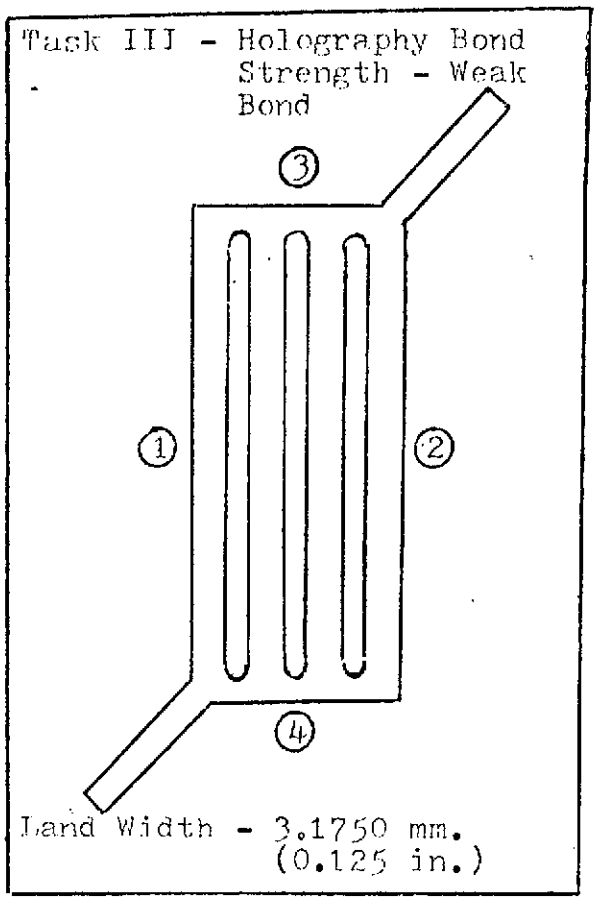


19.0×10^5 N/M^2
(275 PSI)



50.0×10^5 N/M^2
(725 PSI)

ELECTROFORMED PANEL NO. N-22



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.1773	0.2432
②	6.1798	0.2433
③	6.1570	0.2424
④	6.1925	0.2438

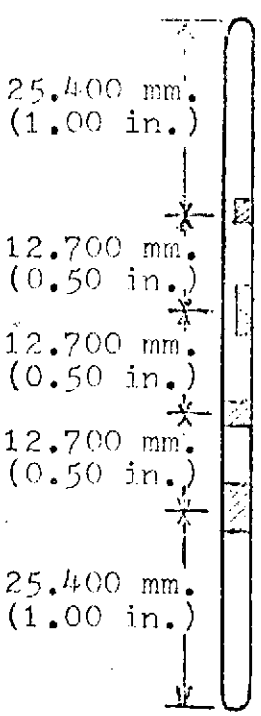
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.3233	0.0521
②	1.3335	0.0525
③	1.4300	0.0563
④	1.3589	0.0535

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable



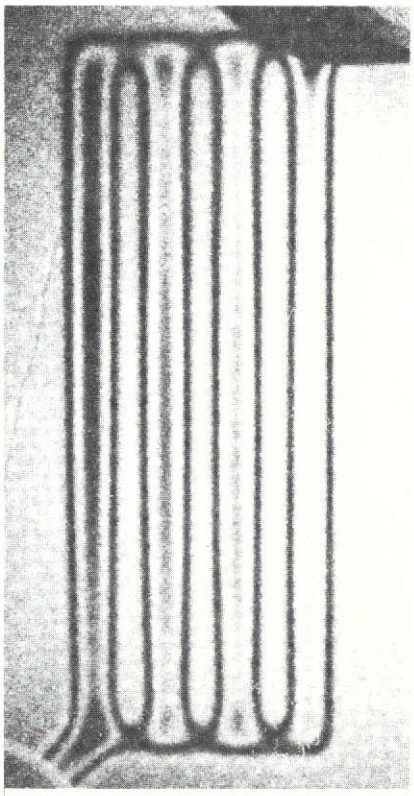
Defect 3.1750 mm. long x ½ land width (0.125 in.)

Defect 6.3500 mm. long x ½ land width (0.250 in.)

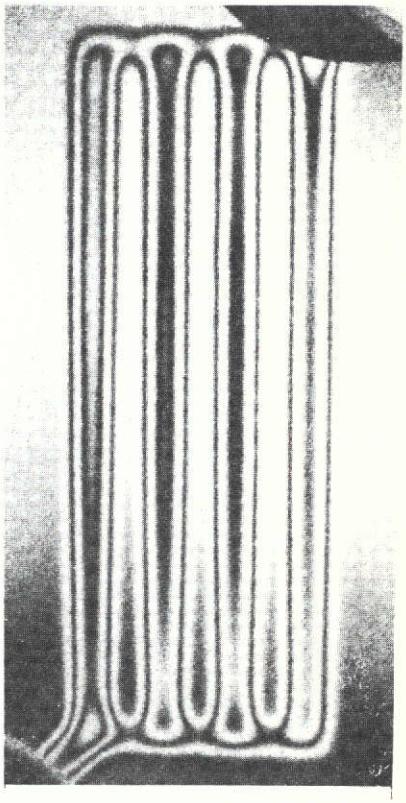
Defect 3.1750 mm. long x land width (0.125 in.)

Defect 6.3500 mm. long x land width (0.250 in.)

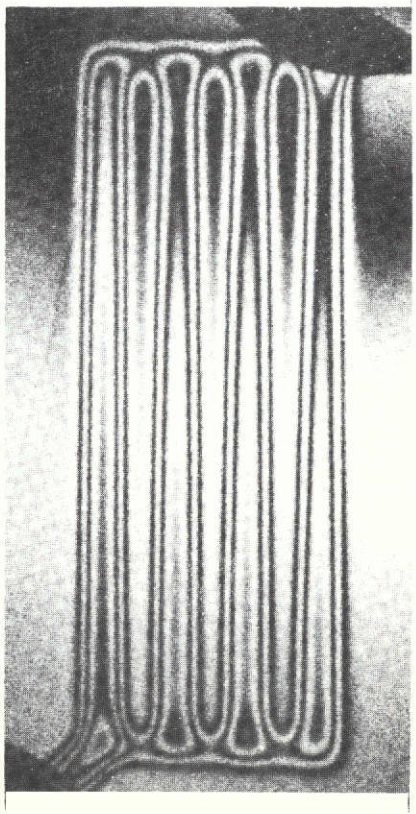
FIGURE B-9



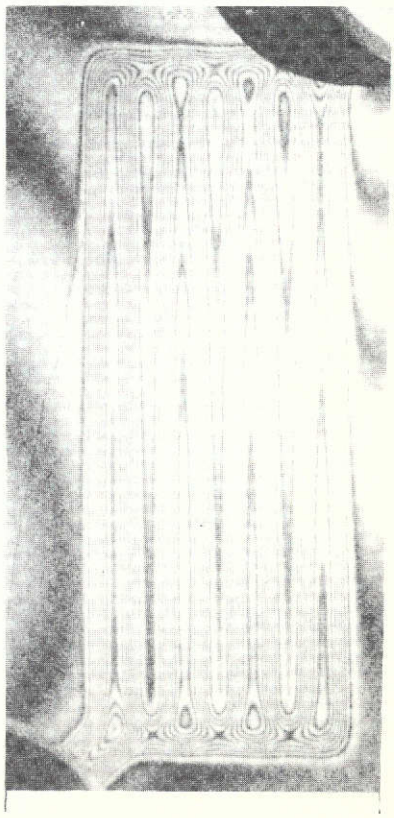
17.25×10^5 N/M^2
(250 PSI)



24.2×10^5 N/M^2
(350 PSI)

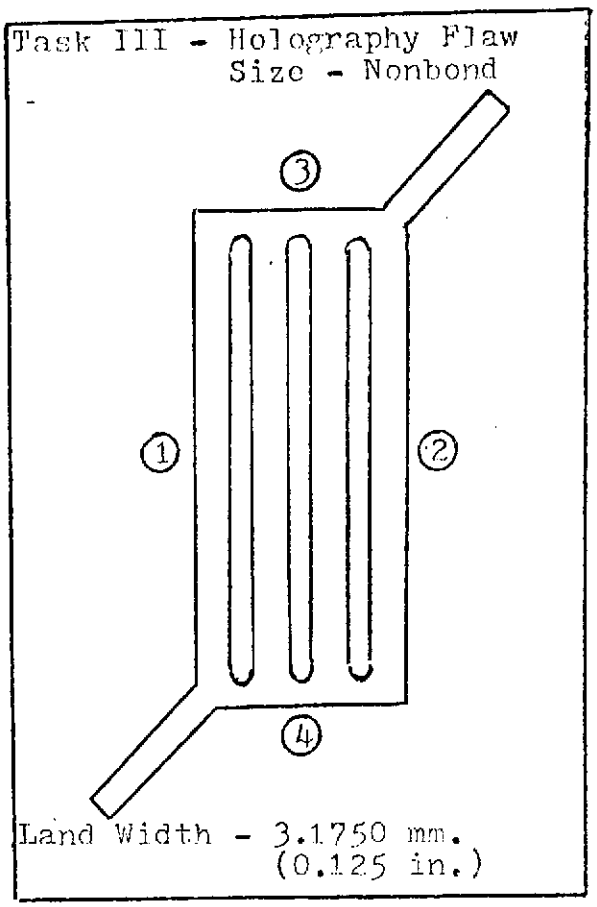


31.0×10^5 N/M^2
(450 PSI)



96.6×10^5 N/M^2
(1400 PSI)

ELECTROFORMED PANEL NO. N-23



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.004 in. (0.1016 mm.)

THICKNESS:	MM.	INCHES
①	6.3348	0.2494
②	6.3348	0.2494
③	6.3017	0.2481
④	6.3576	0.2503

COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4453	0.0569
②	1.4072	0.0554
③	1.4656	0.0577
④	1.3792	0.0543

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable

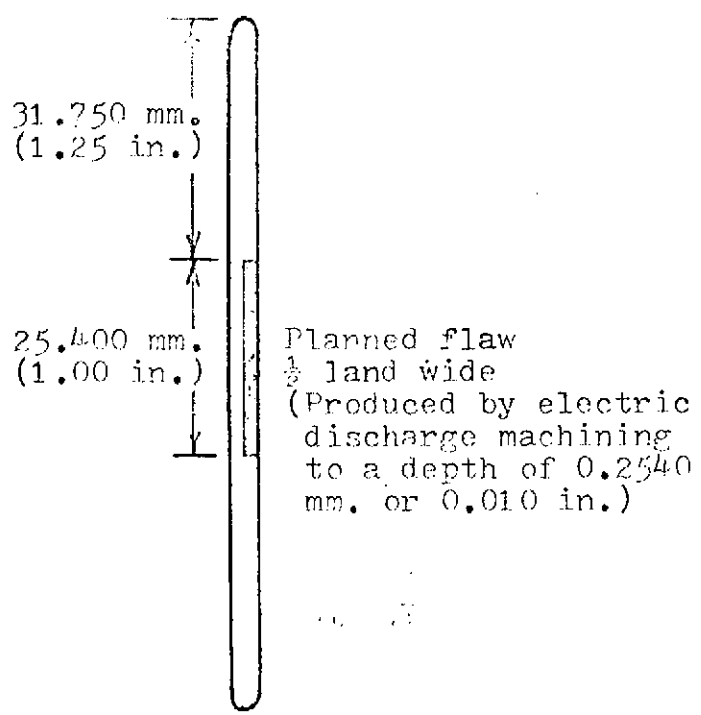
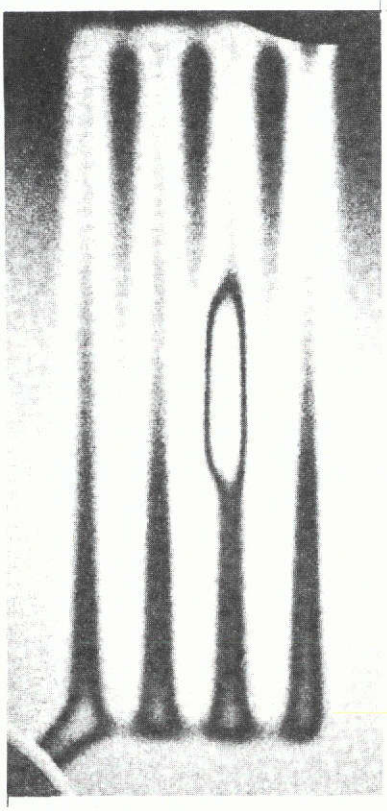
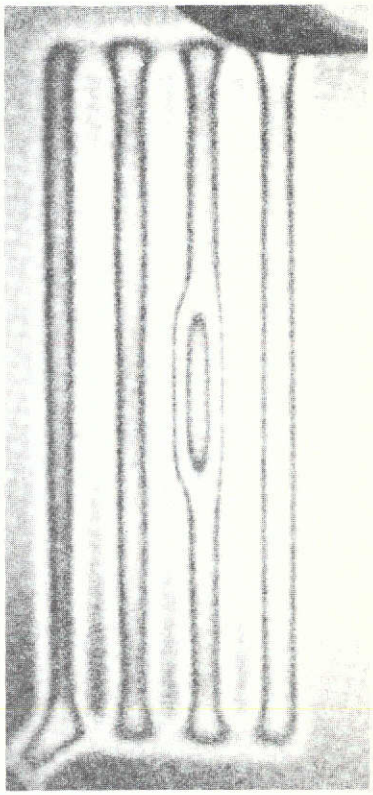


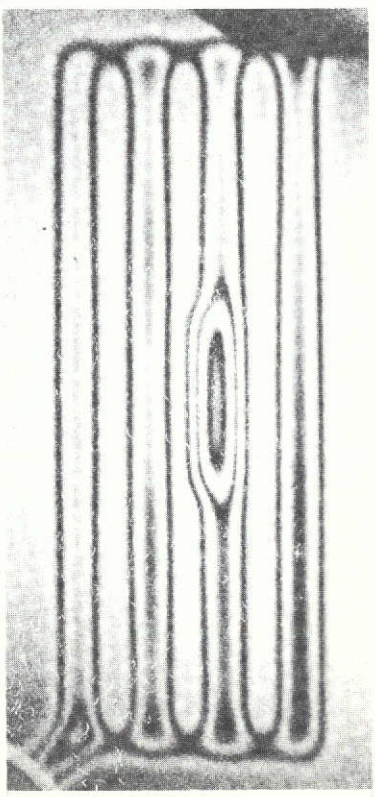
FIGURE B-10



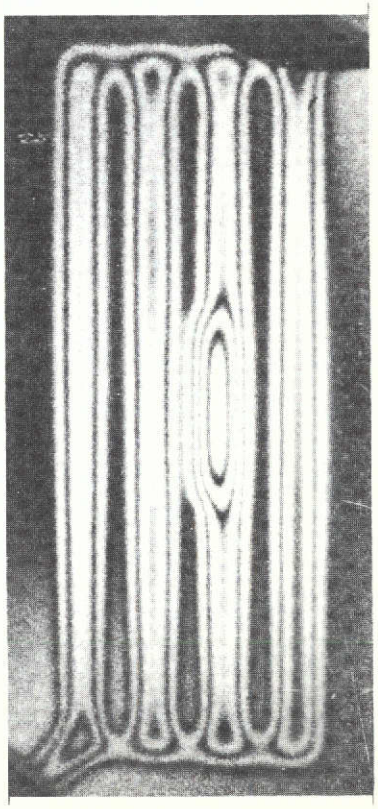
10.4×10^5 N/M^2
(150 PSI)



17.25×10^5 N/M^2
(250 PSI)

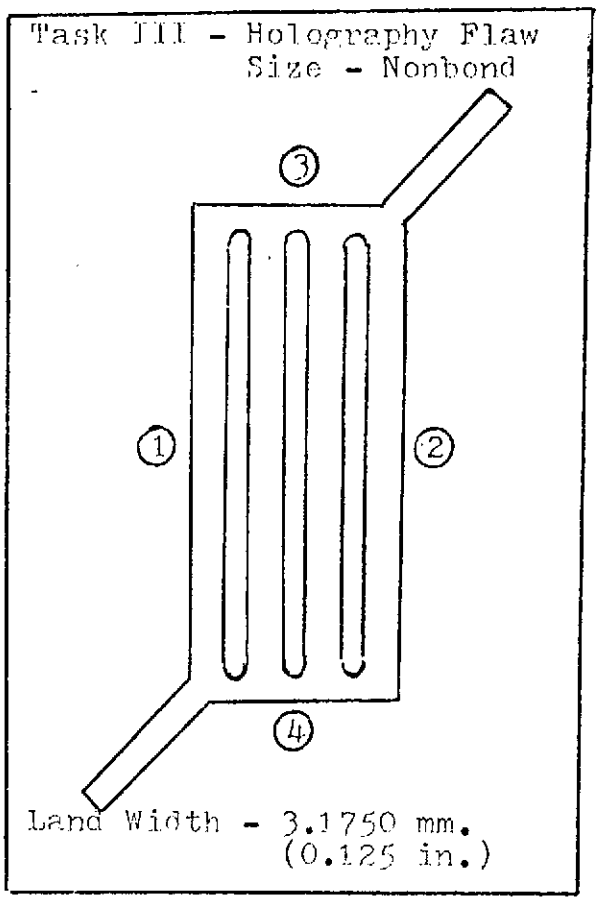


24.2×10^5 N/M^2
(350 PSI)



31.0×10^5 N/M^2
(450 PSI)

ELECTROFORMED PANEL NO. N-24



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.2281	0.2452
②	6.2078	0.2444
③	6.2103	0.2445
④	6.1925	0.2438

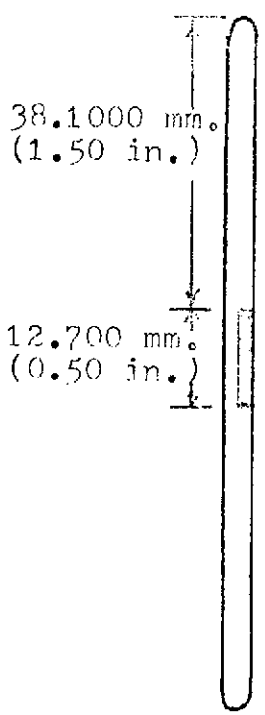
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4021	0.0552
②	1.4173	0.0558
③	1.4351	0.0565
④	1.4351	0.0565

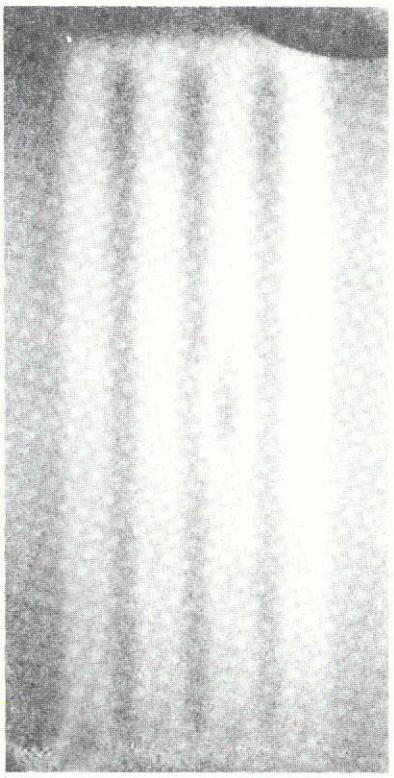
CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable

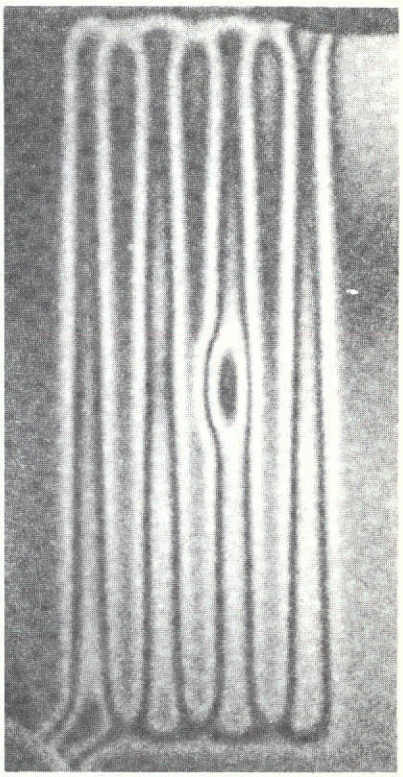


Planned flaw $\frac{1}{2}$ land wide
(produced by electric discharge machining to a depth of 0.2540 mm. or 0.010 in.)

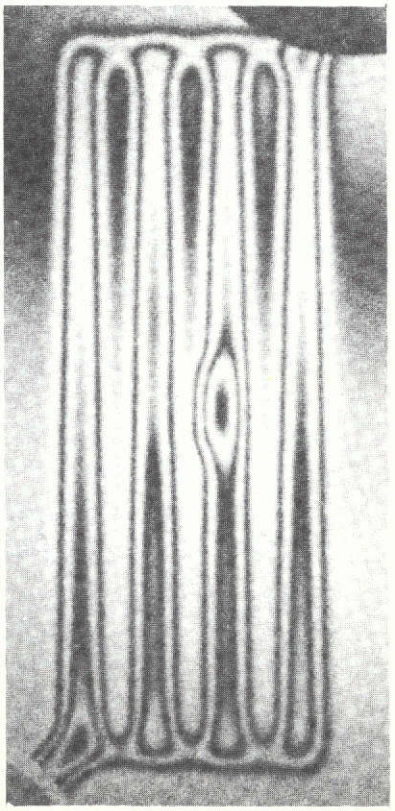
FIGURE B-11



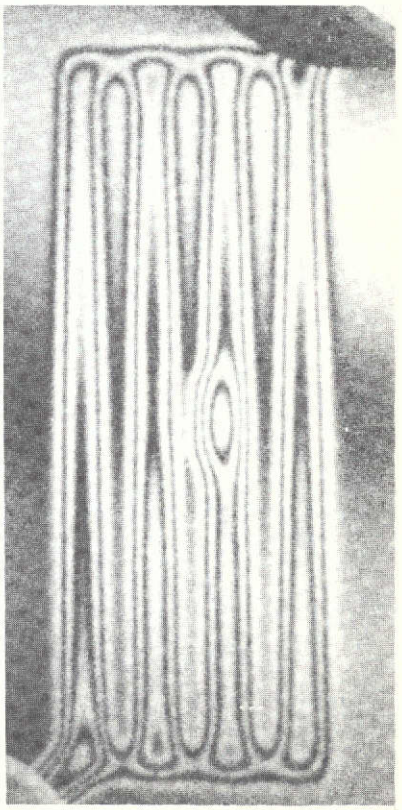
50 PSI



250 PSI

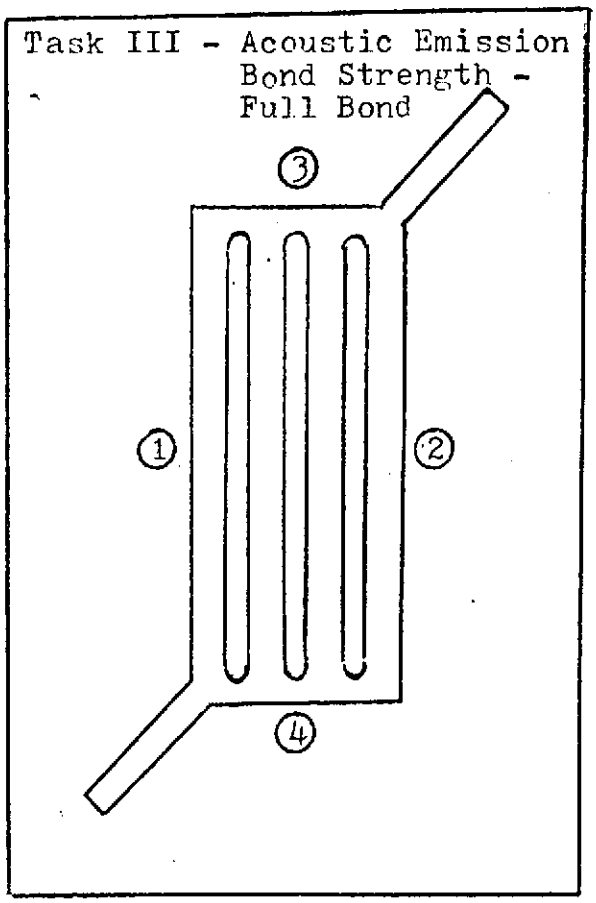


350 PSI



450 PSI

ELECTROFORMED PANEL NO. N-10



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.3449	0.2498
②	6.3475	0.2499
③	6.2586	0.2464
④	6.3271	0.2491

COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4656	0.0577
②	1.4961	0.0589
③	1.5265	0.0601
④	1.4783	0.0582

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable

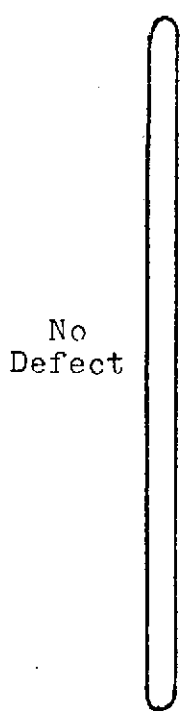
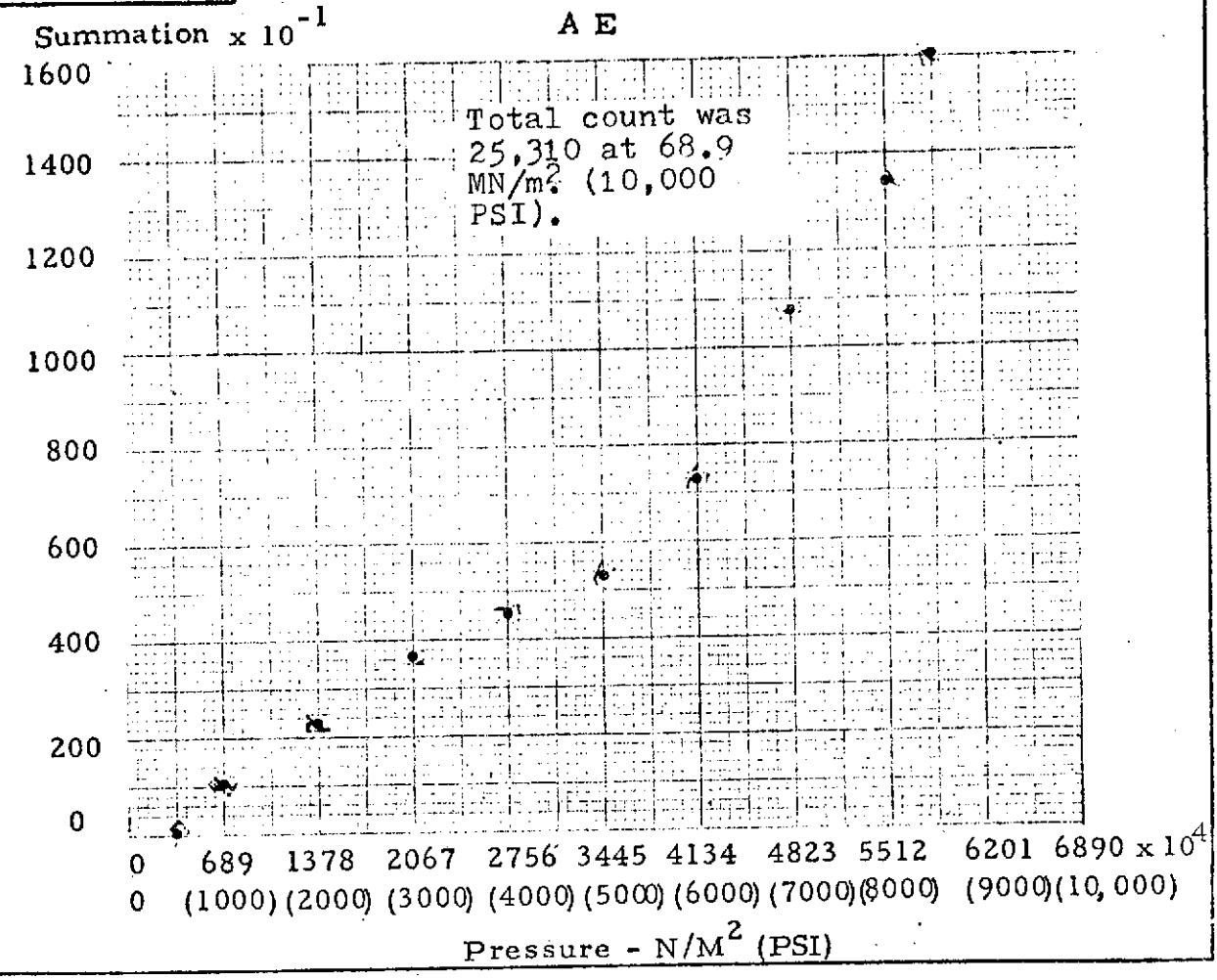


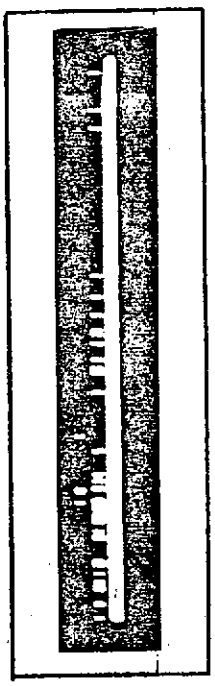
FIGURE B-12

Panel No. N-10



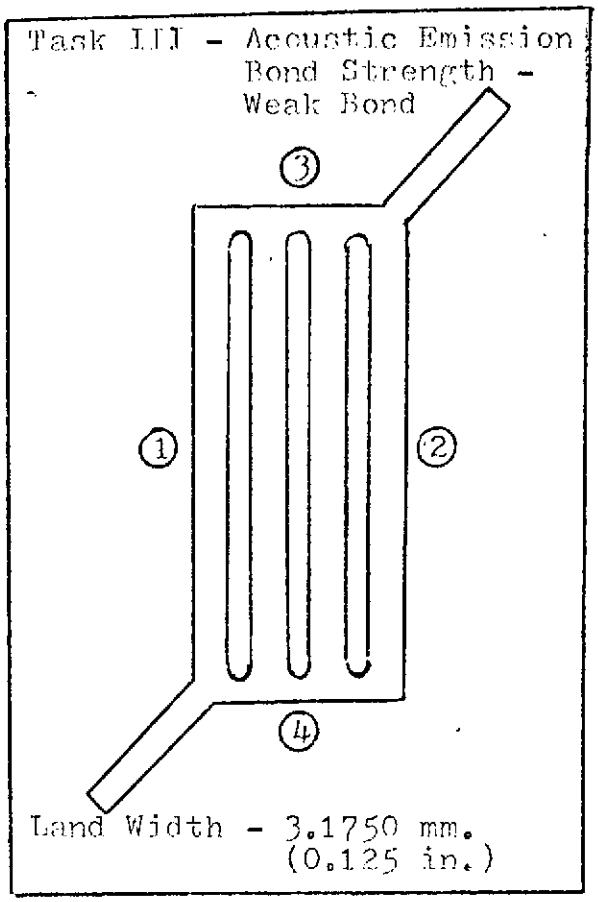
HNDT

AE
FLAW LOCATOR
CENTER LAND



UT

ELECTROFORMED PANEL NO. N-44



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.0005 in. (0.0127 mm.)

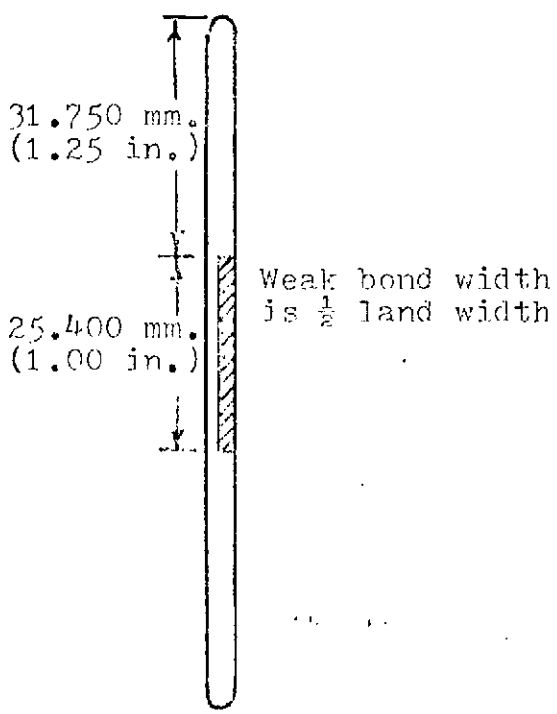
THICKNESS:	MM.	INCHES
①	6.3144	0.2486
②	6.3170	0.2487
③	6.3297	0.2492
④	6.3246	0.2490

COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.4859	0.0585
②	1.4707	0.0579
③	1.4681	0.0578
④	1.4681	0.0578

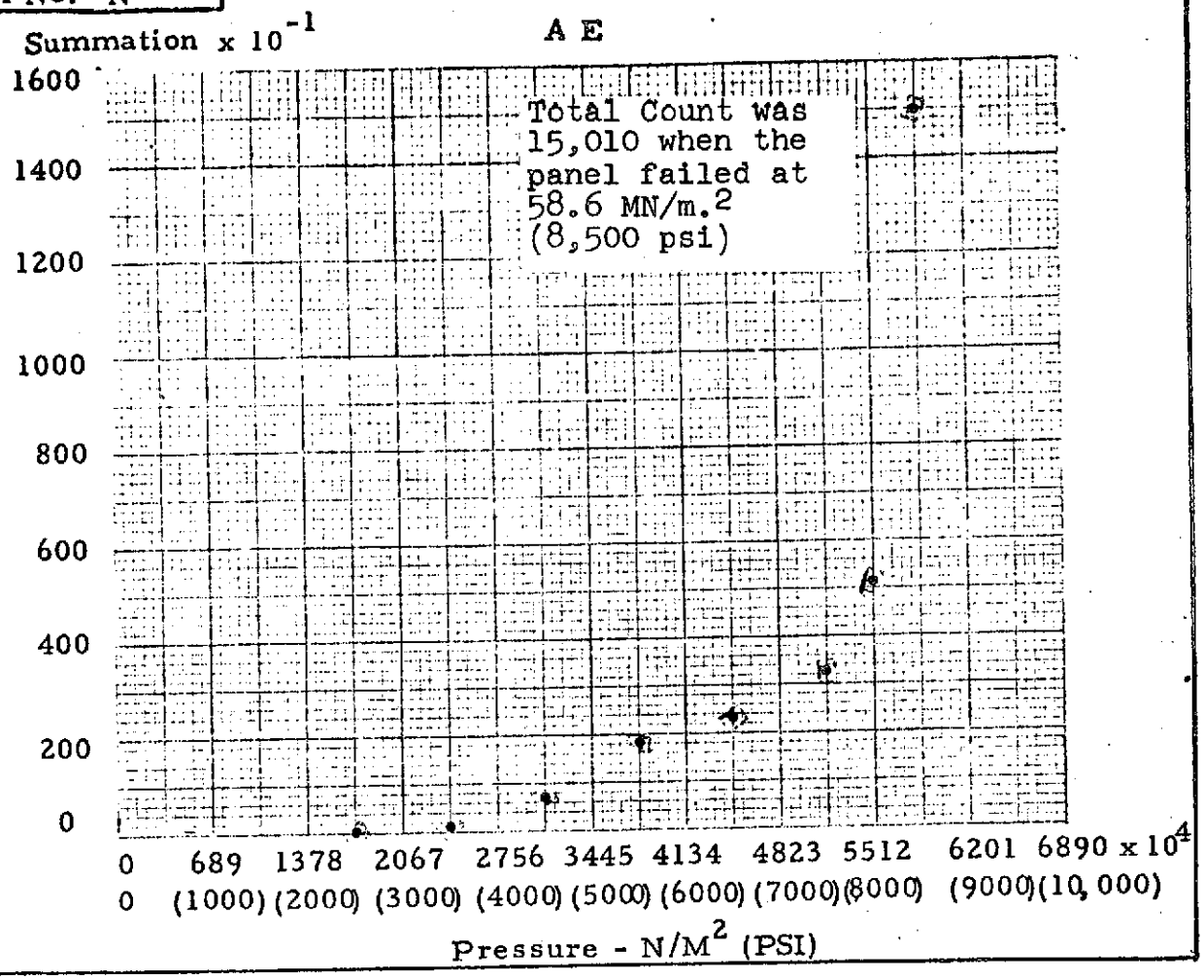
CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS: Not Applicable

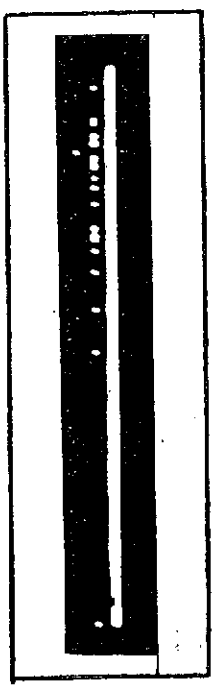
FIGURE B-13

Panel No. N-44

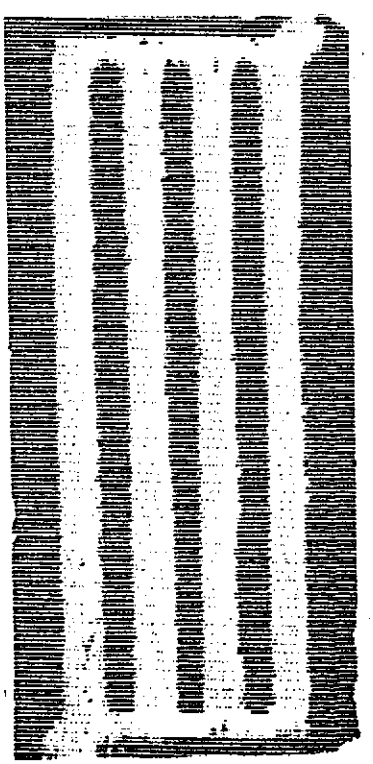


HNDT

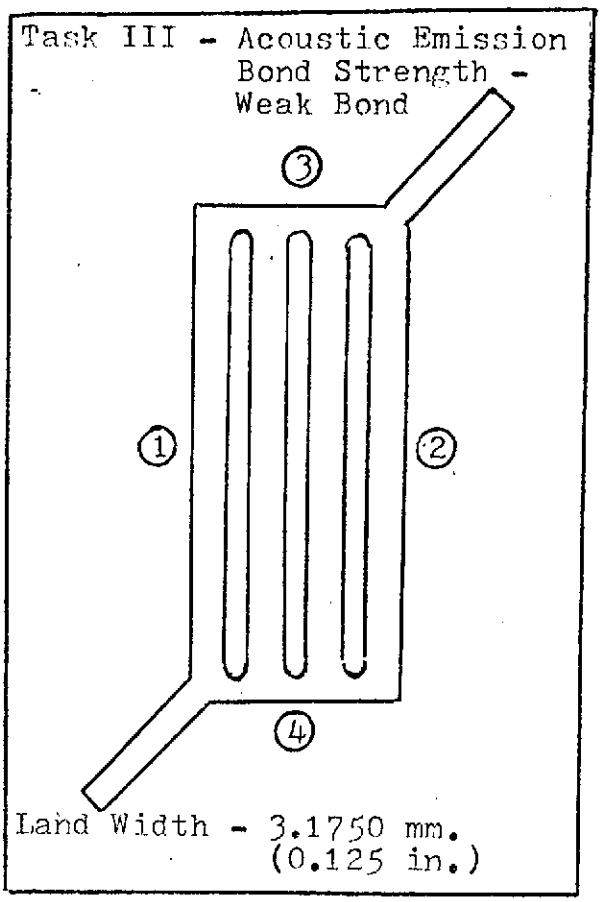
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-45



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.0015 in. (0.0381 mm.)

THICKNESS:	MM.	INCHES
①	6.2738	0.2470
②	6.2763	0.2471
③	6.2636	0.2466
④	6.2763	0.2471

COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.8509	0.0335
②	0.8484	0.0334
③	0.8204	0.0323
④	0.8712	0.0343

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable

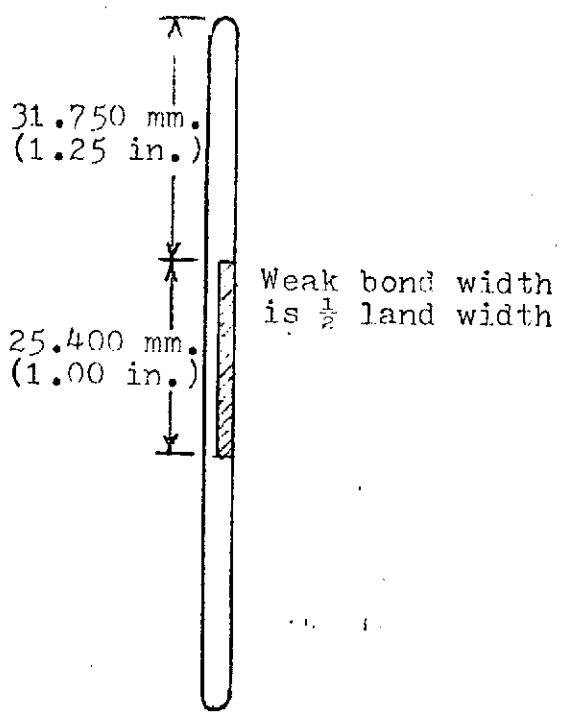
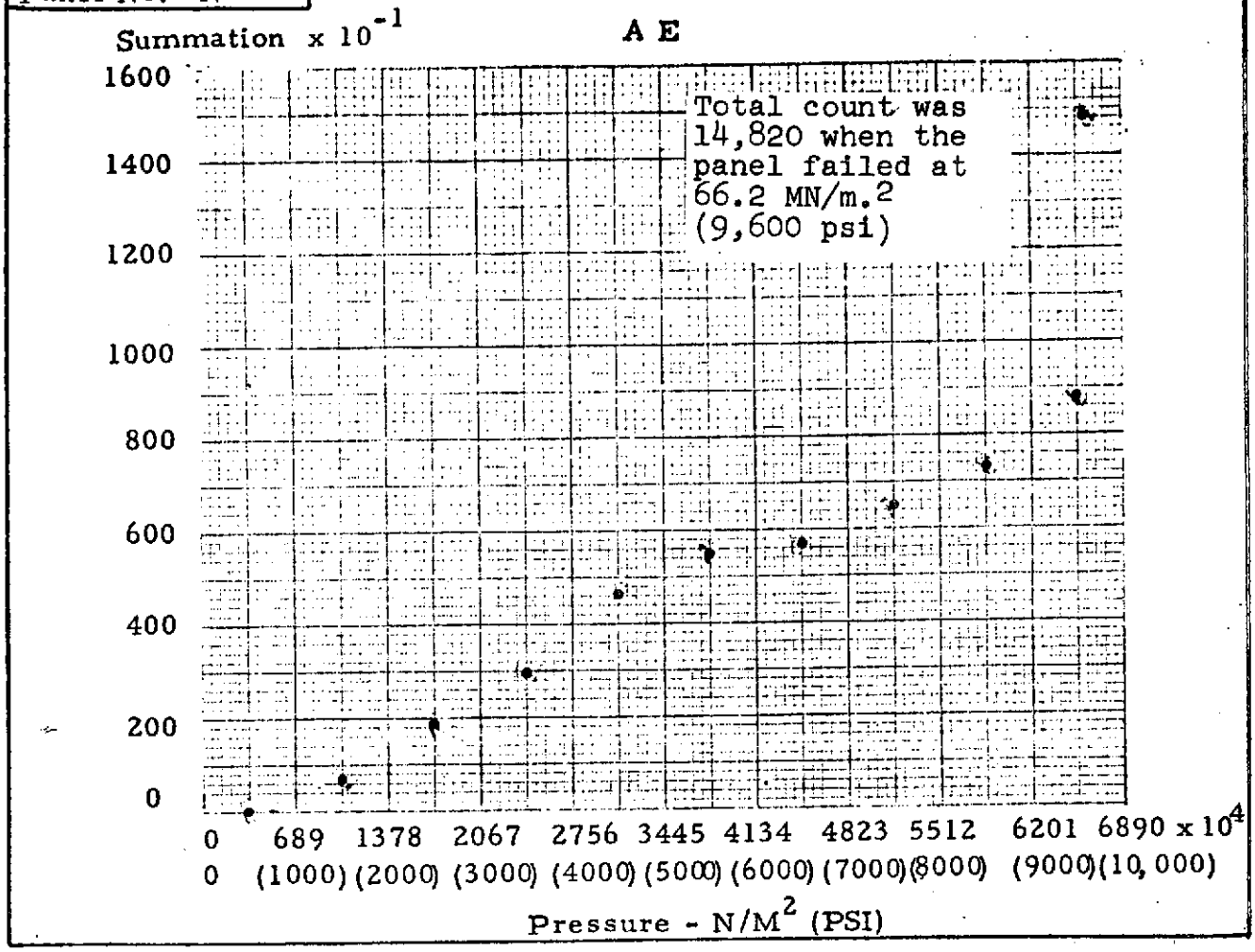
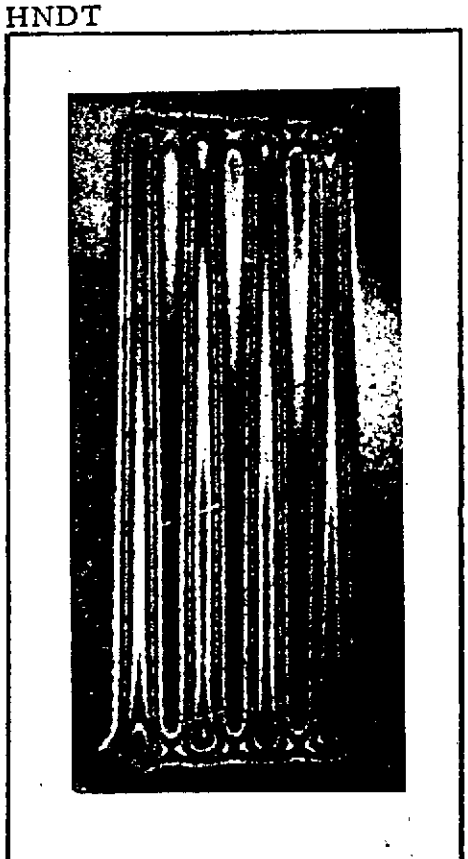


FIGURE B-14

Panel No. N-45

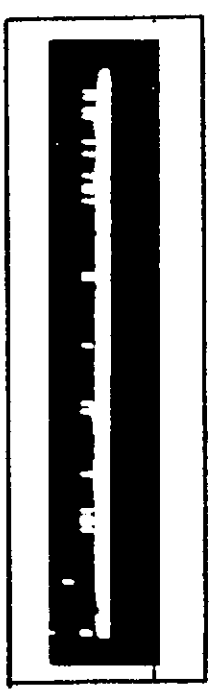


HNDT

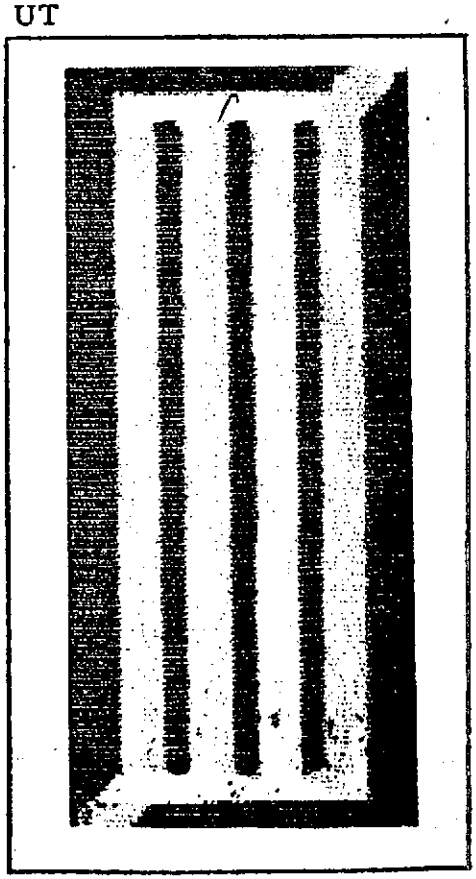


Press. 20.7 x 10^5 N/M^2
(300 PSI)

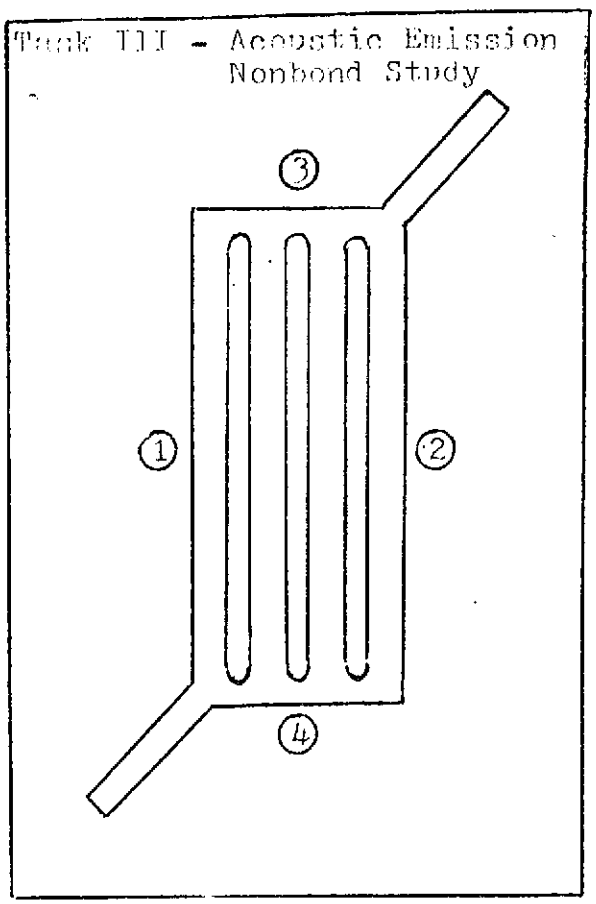
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-27



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.3551	0.2502
②	6.3475	0.2499
③	6.3094	0.2484
④	6.3525	0.2501

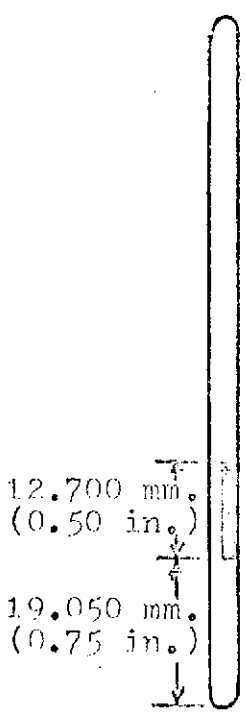
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.3462	0.0530
②	1.2954	0.0510
③	1.3386	0.0527
④	1.3411	0.0528

CENTER LAND DEFECT

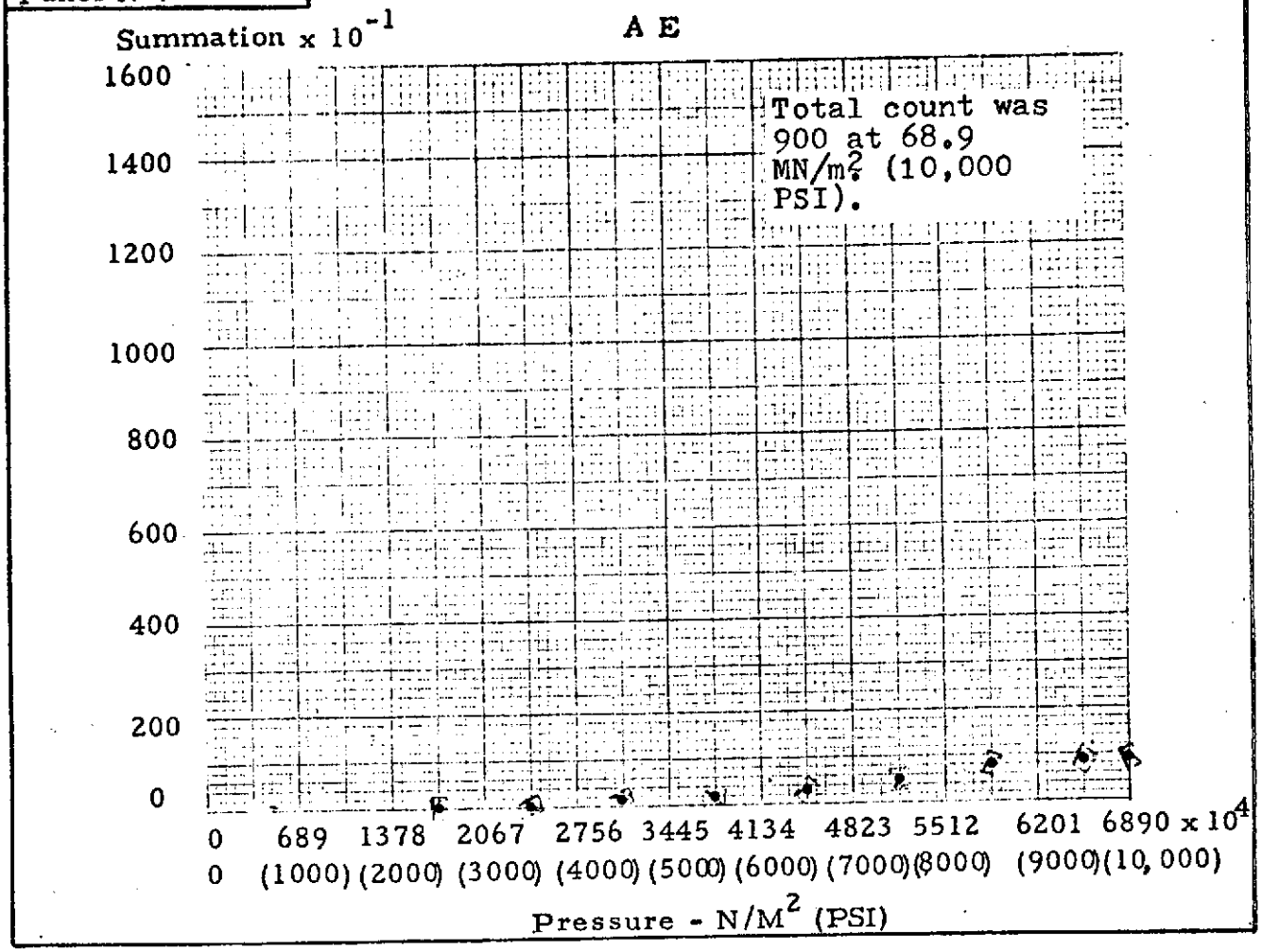
METALLOGRAPHIC ANALYSIS: Not Applicable



Planned flaw ¾ land wide
(produced by electric discharge
machining to a depth of
0.2540 mm. or 0.010 in.)

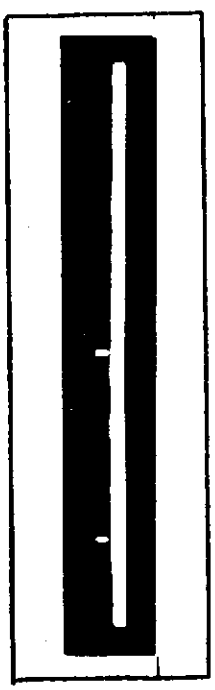
FIGURE B-15

Panel No. N-27

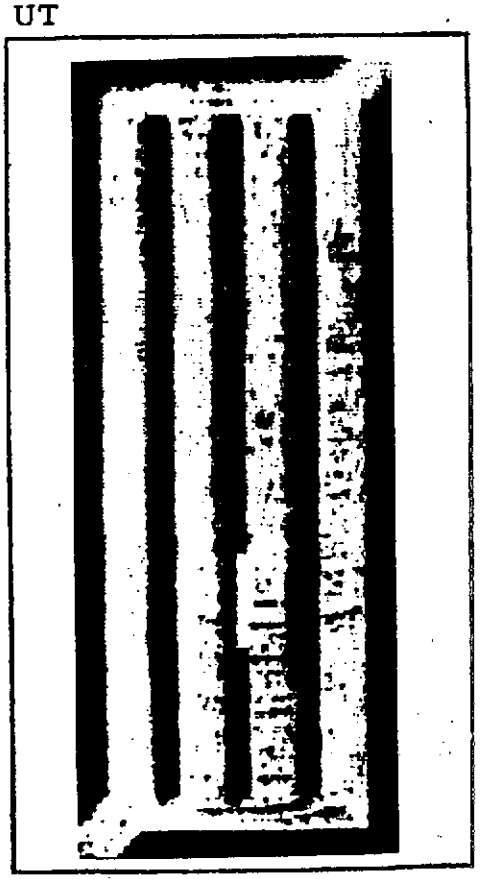


HNDT

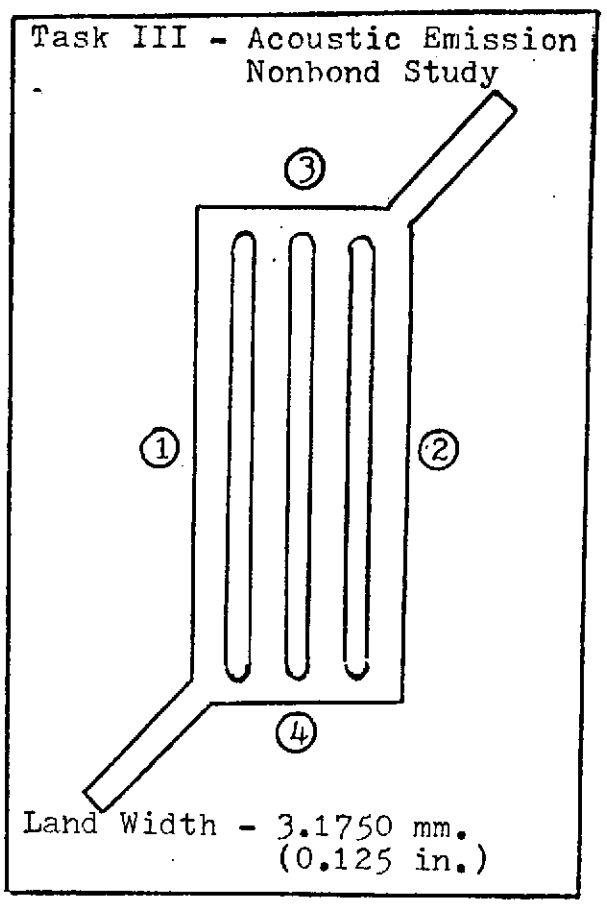
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-28 "A"



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.0503	0.2382
②	6.0579	0.2385
③	6.1163	0.2408
④	6.1239	0.2411

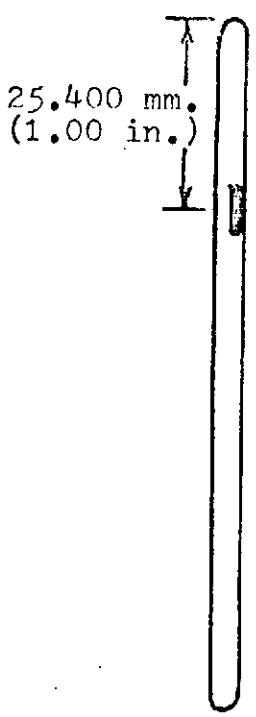
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.0643	0.0419
②	1.0719	0.0422
③	0.9881	0.0389
④	1.0084	0.0397

CENTER LAND DEFECT

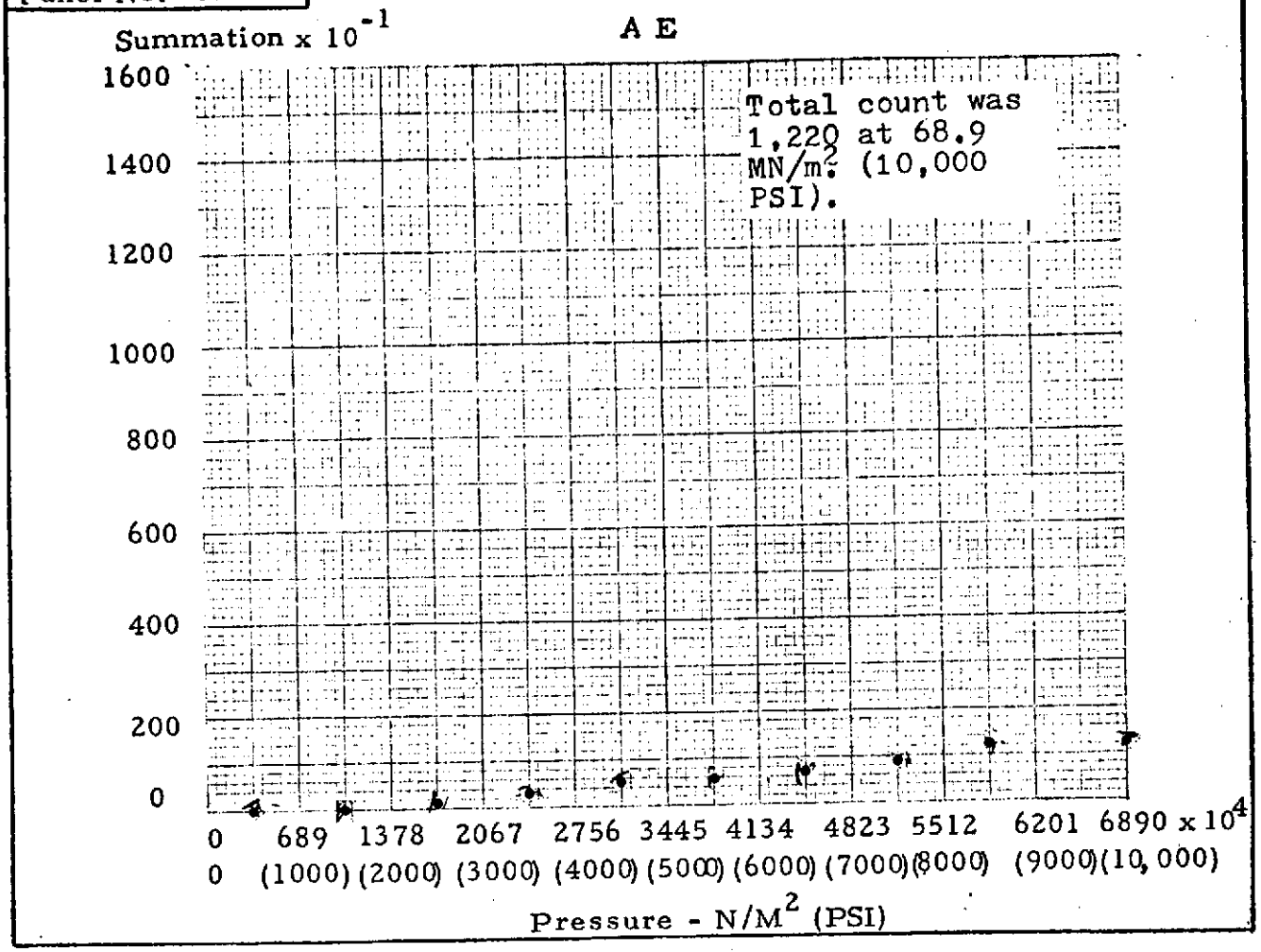
METALLOGRAPHIC ANALYSIS: Not Applicable



Planned flaw 6.3500 mm. long x $\frac{1}{2}$ land width (0.25 in.)
(Produced by electric discharge machining to a depth of 0.2540 mm. or 0.010 in.)

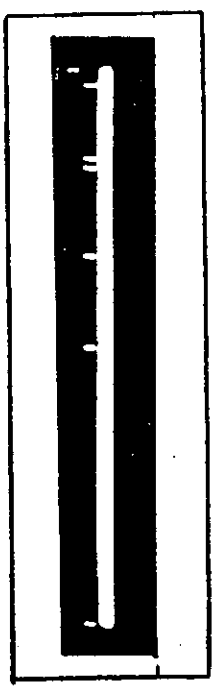
FIGURE B-16

Panel No. N-28A

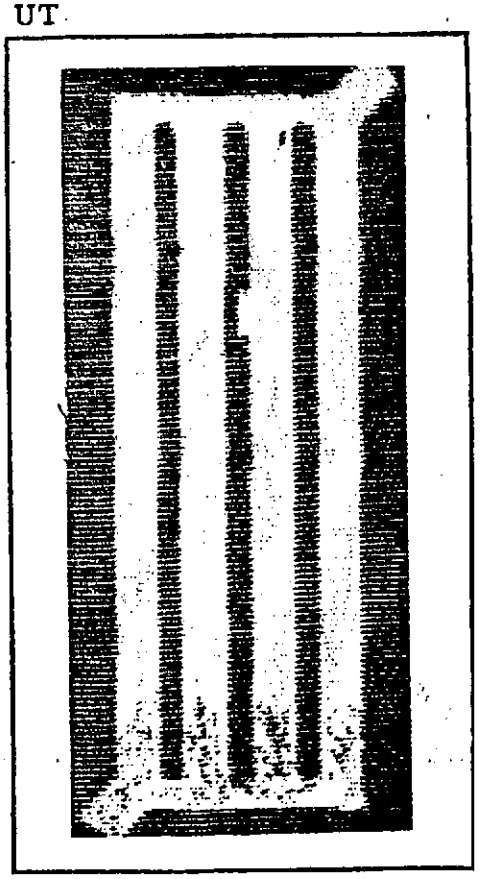


HNDT

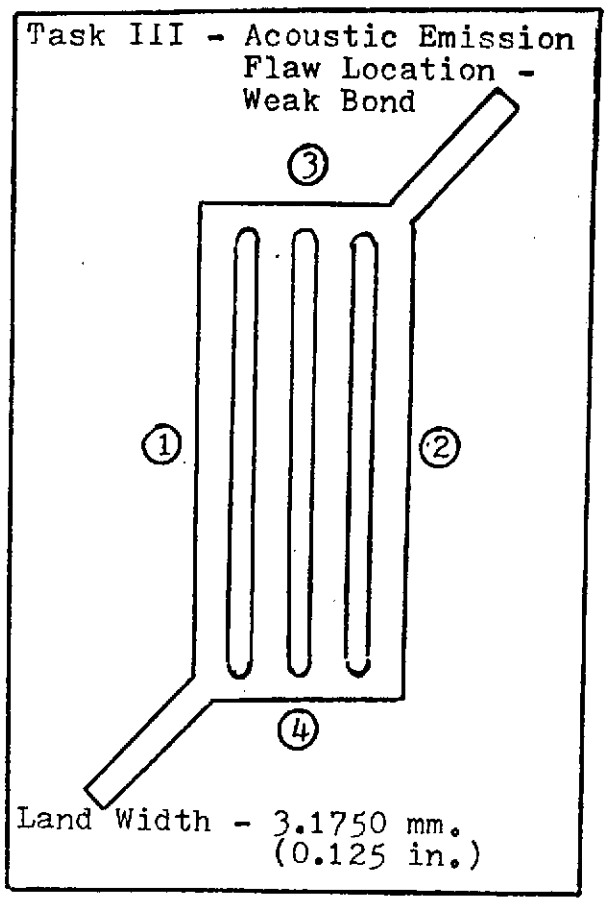
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-43



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.006 in. (0.1524 mm.)

THICKNESS:	MM.	INCHES
①	6.2281	0.2452
②	6.2560	0.2463
③	6.2484	0.2460
④	6.2484	0.2460

COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.2040	0.0474
②	1.2217	0.0481
③	1.3056	0.0514
④	1.3132	0.0517

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS: Not Applicable

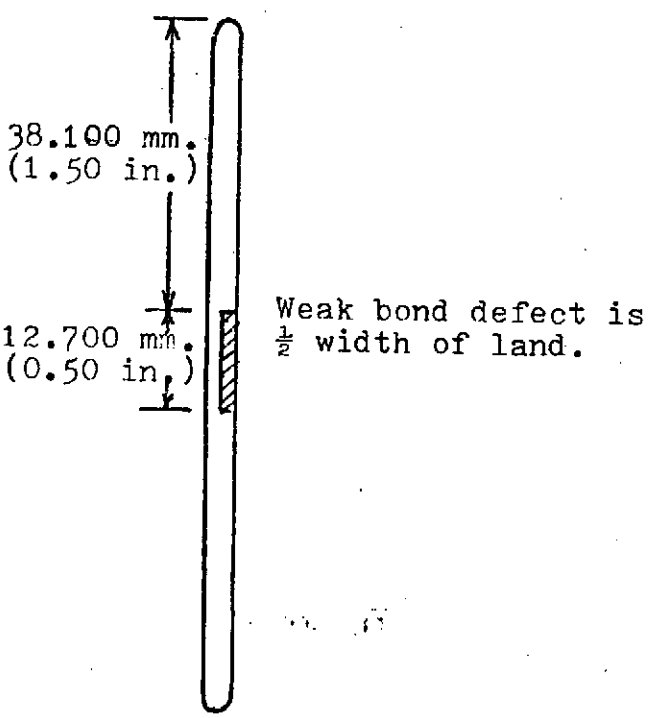
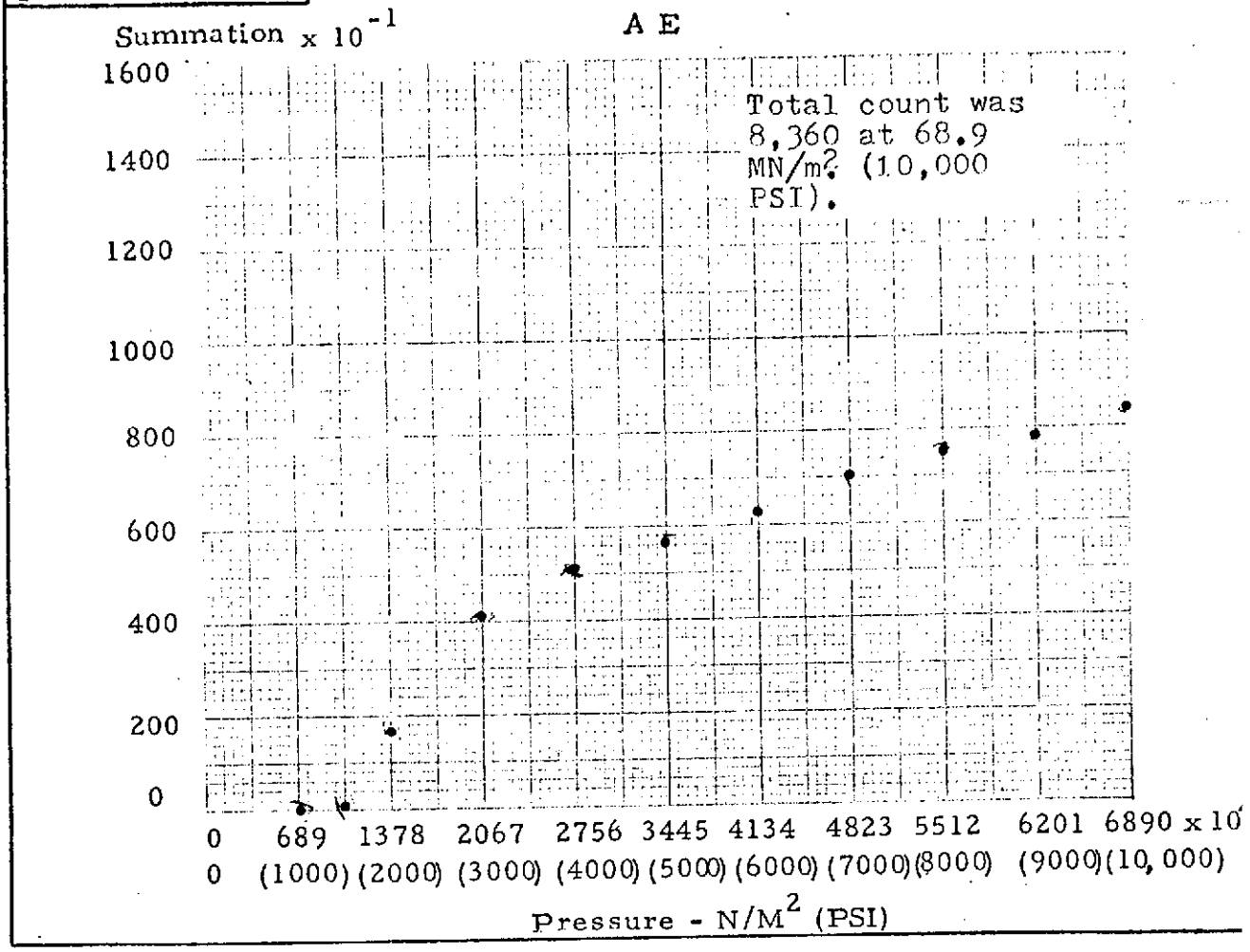


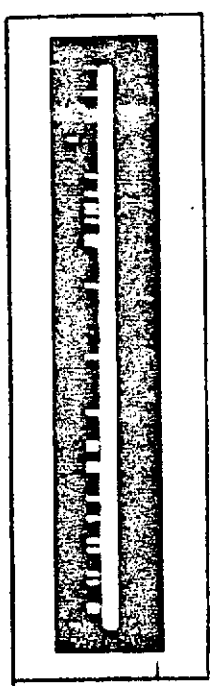
FIGURE B-17

Panel No. N-43

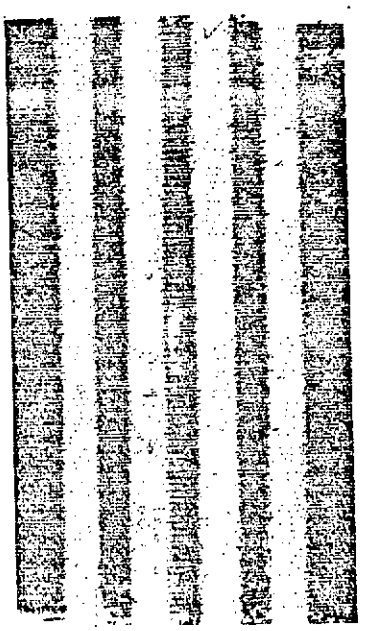


HNDT

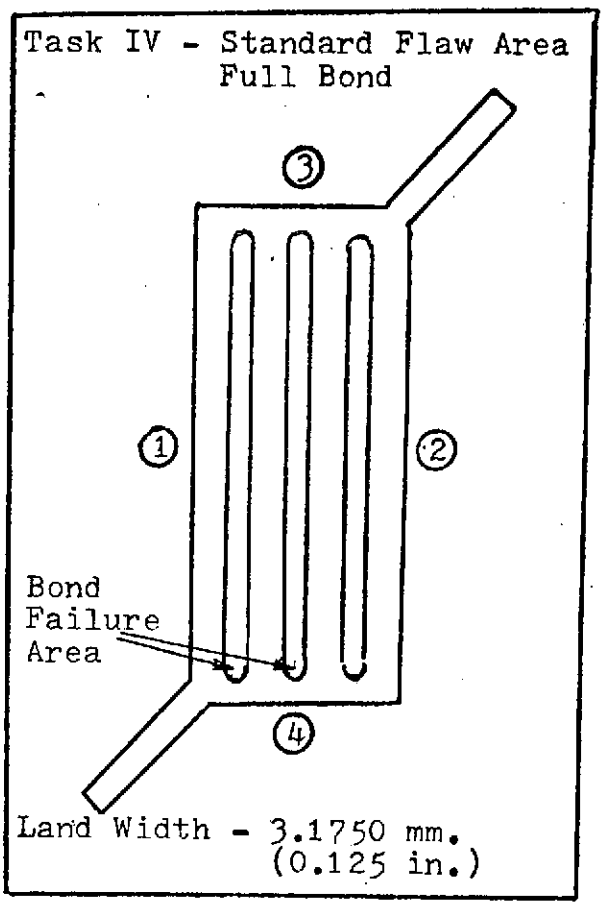
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-11 "A"



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.0015 in. (0.0381 mm.)

THICKNESS:	MM.	INCHES
①	6.1976	0.2440
②	6.1620	0.2426
③	6.2179	0.2448
④	6.1646	0.2427

COVERPLATE

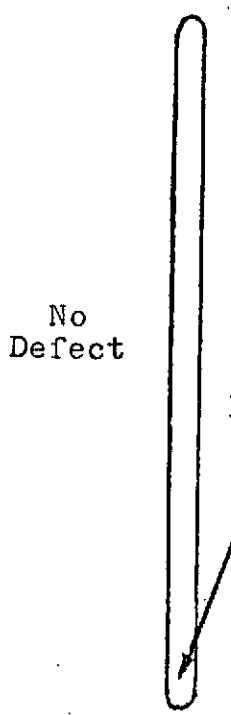
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9957	0.0392
②	1.0058	0.0396
③	0.9525	0.0375
④	1.0033	0.0395

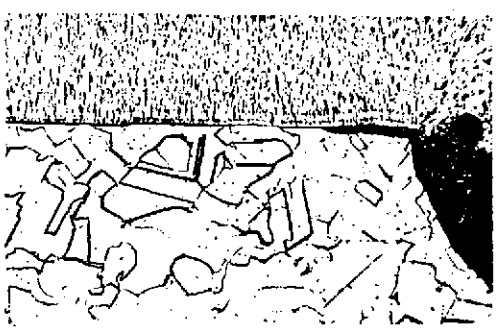
PRESSURE REQUIRED TO FAIL BOND:

Bonds failed at a pressure of 6.9×10^7 N/m^2 (10,000 psi). Failure occurred at ends of Lands 1 and 2.

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

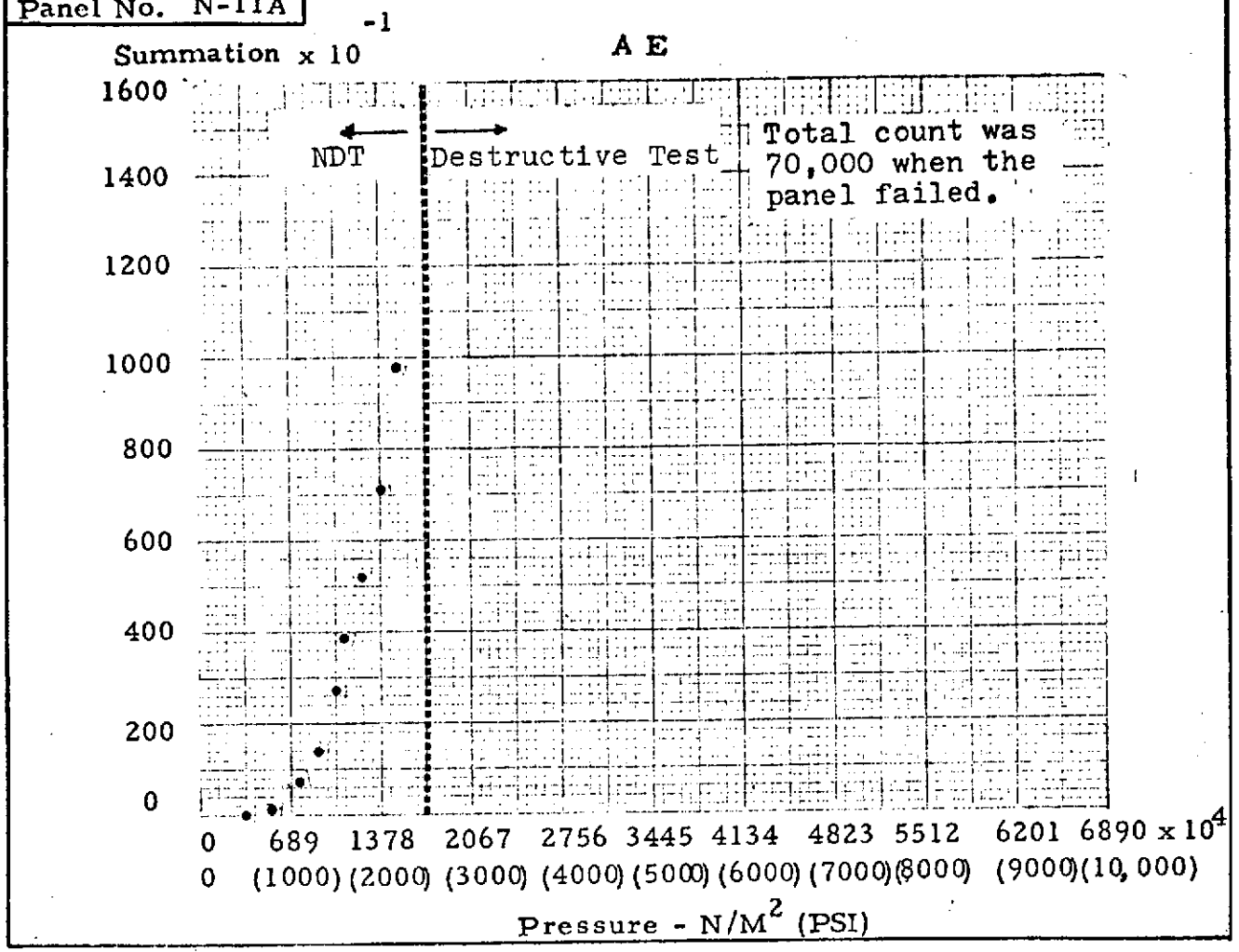


Section from lower end of first land showing edge bond separation. Magnification 50X.

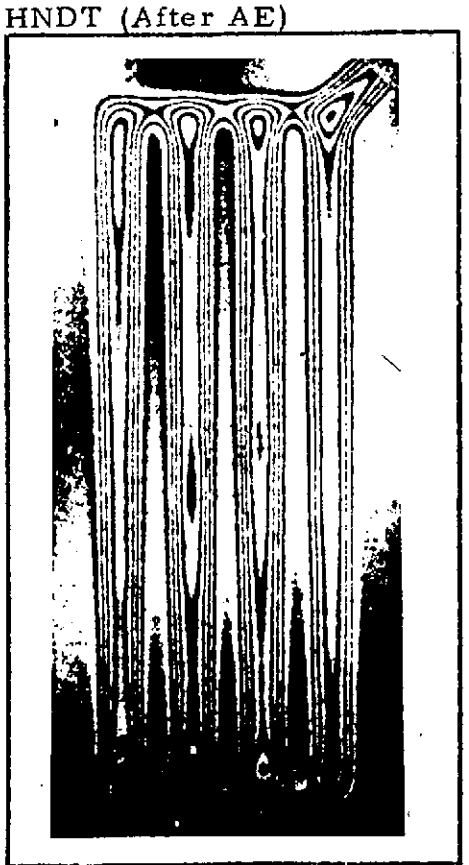
Section from lower end of second land showing bond intact. Failure appears to be starting. Magnification 50X.

FIGURE C-1

Panel No. N-11A

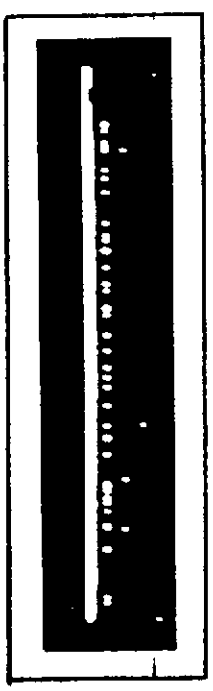


HNDT (After AE)

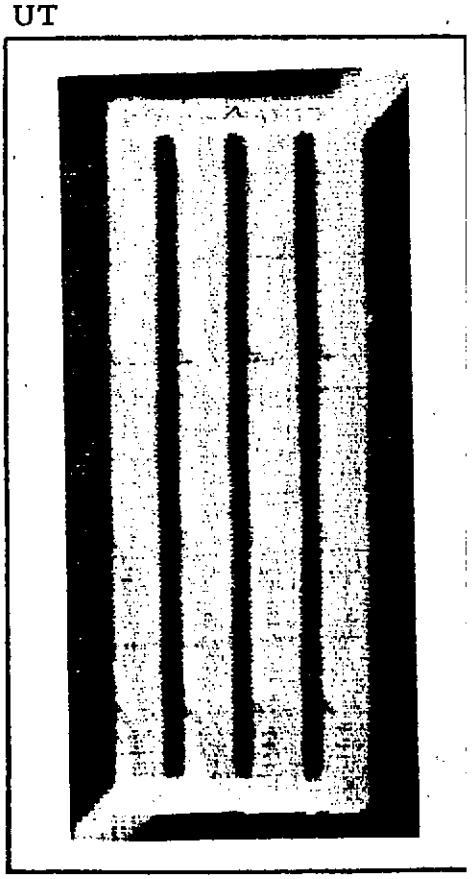


Press. - 20.7×10^5 N/M^2
(300 PSI)

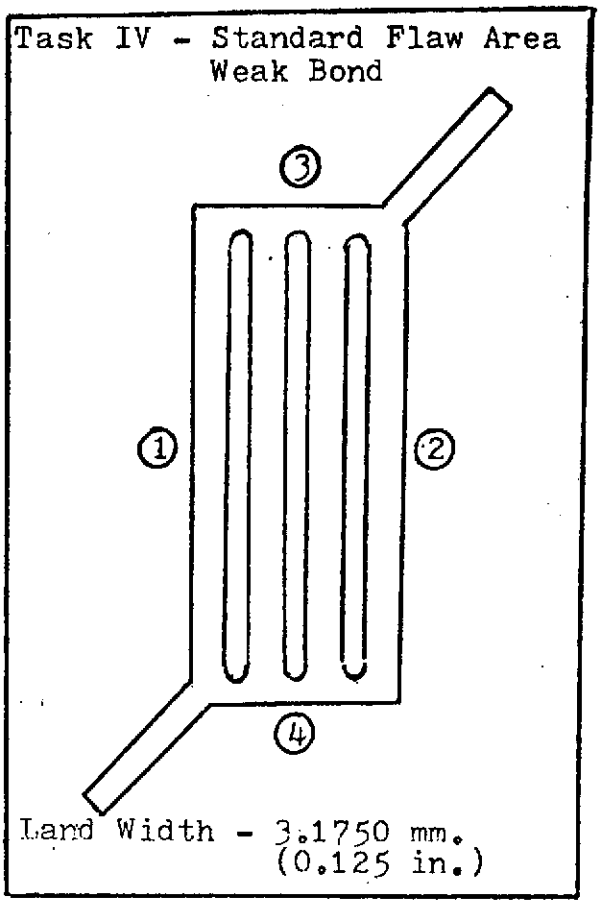
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-29



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: ±0.0015 in. (0.0381 mm.)

THICKNESS:	MM.	INCHES
①	6.3119	0.2485
②	6.3144	0.2486
③	6.3068	0.2483
④	6.2738	0.2470

COVERPLATE

MATERIAL: Electroformed Nickel

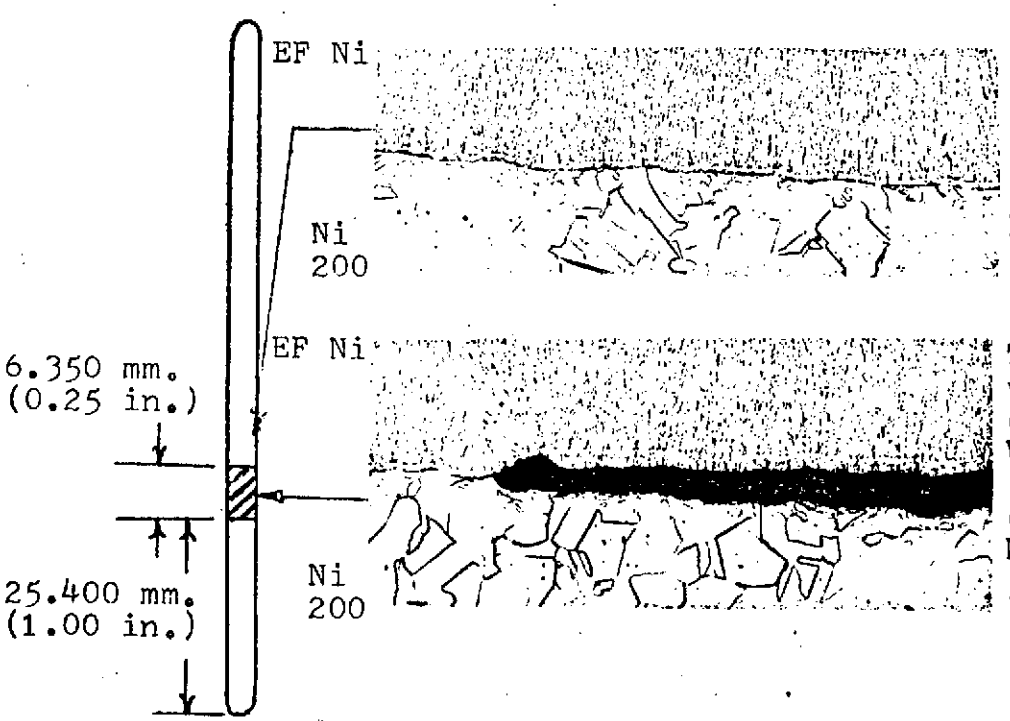
THICKNESS:	MM.	INCHES
①	0.9855	0.0388
②	0.9576	0.0377
③	0.9525	0.0375
④	1.0008	0.0394

PRESSURE REQUIRED TO FAIL BOND:

Panel exhibited slight bulging at 6.90×10^7 N/m^2 (10,000 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

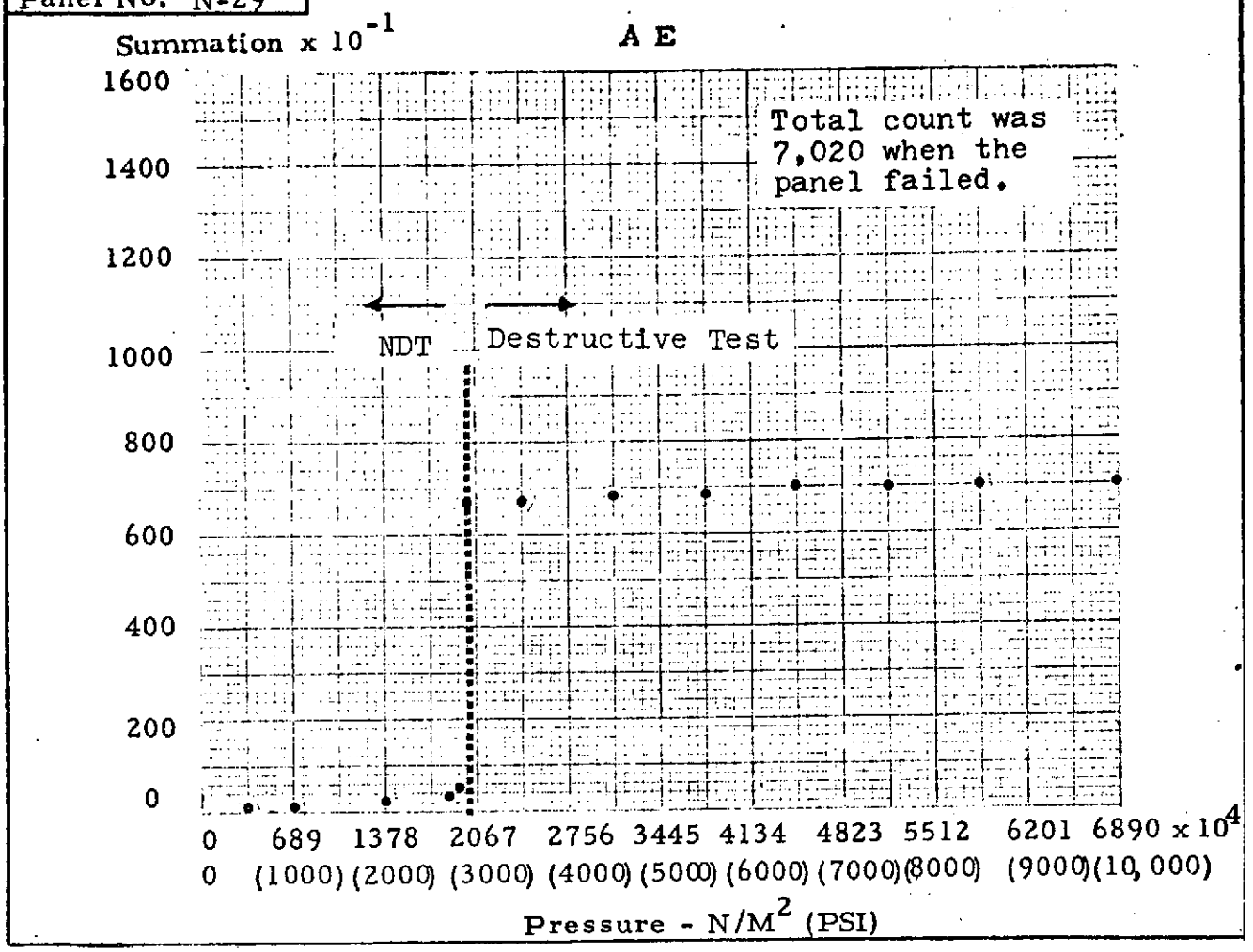


Section of the planned full bond adjacent to weak bond. No failure. Magnification 50X.

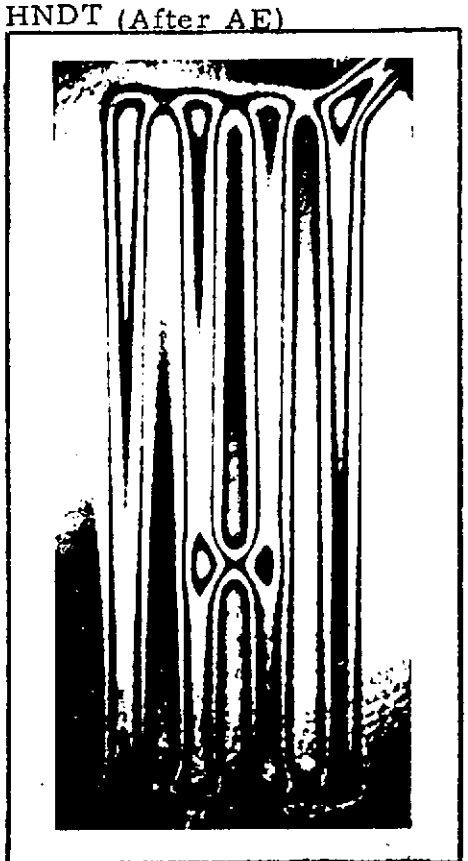
The planned weak bond failed as shown. Weak bond was stronger than expected. Magnification 50X.

FIGURE C-2

Panel No. N-29

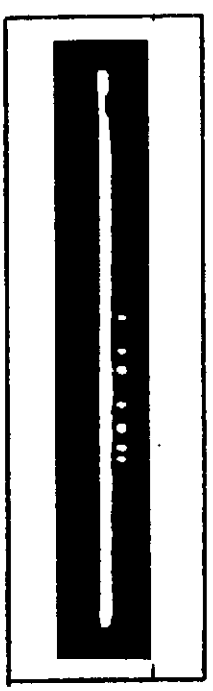


HNDT (After AE)

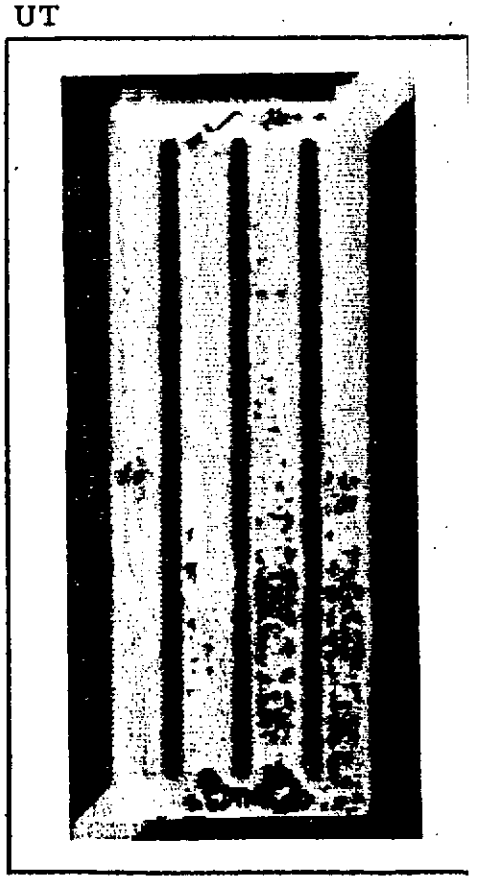


Press. - 13.8 x 10^5 N/M^2
(200 PSI)

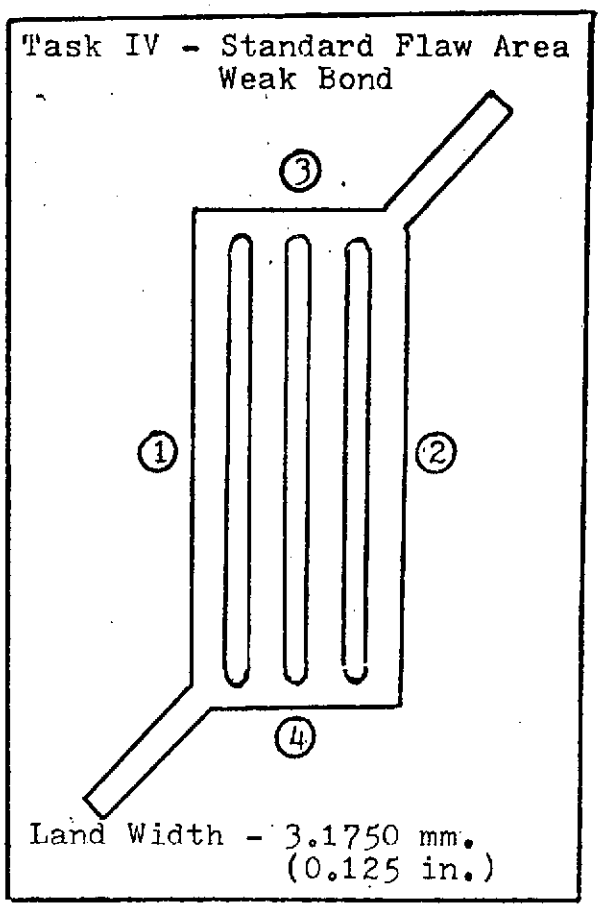
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N -30



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.006 in. (0.1524 mm.)

THICKNESS:	MM.	INCHES
①	6.2662	0.2467
②	6.2687	0.2468
③	6.2738	0.2470
④	6.2636	0.2466

COVERPLATE

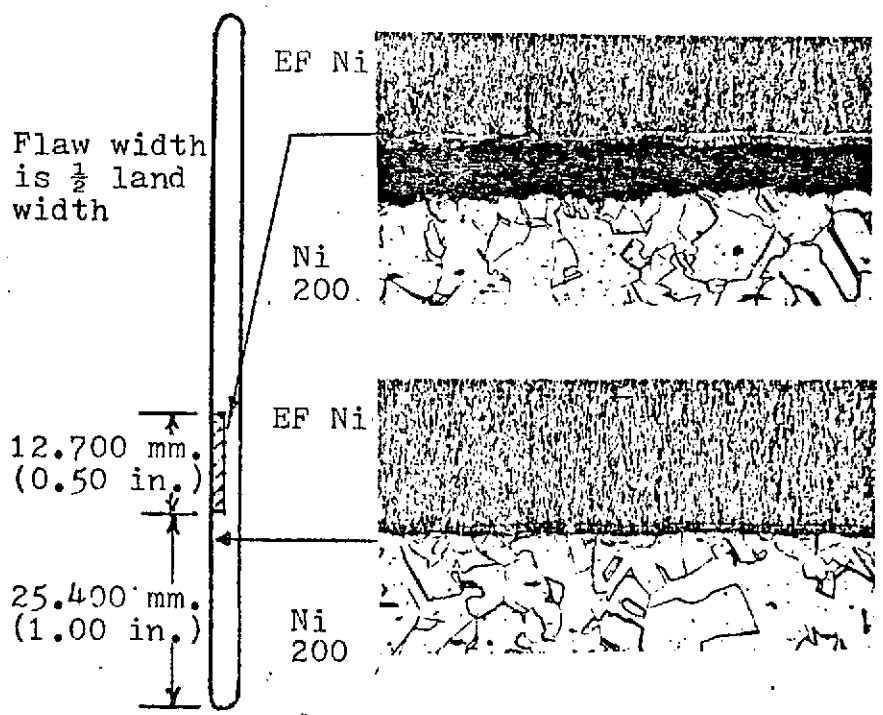
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9957	0.0392
②	0.9677	0.0381
③	0.9474	0.0373
④	0.9601	0.0378

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 6.90×10^7 N/m^2 (10,000 psi).

CENTER LAND DEFECT



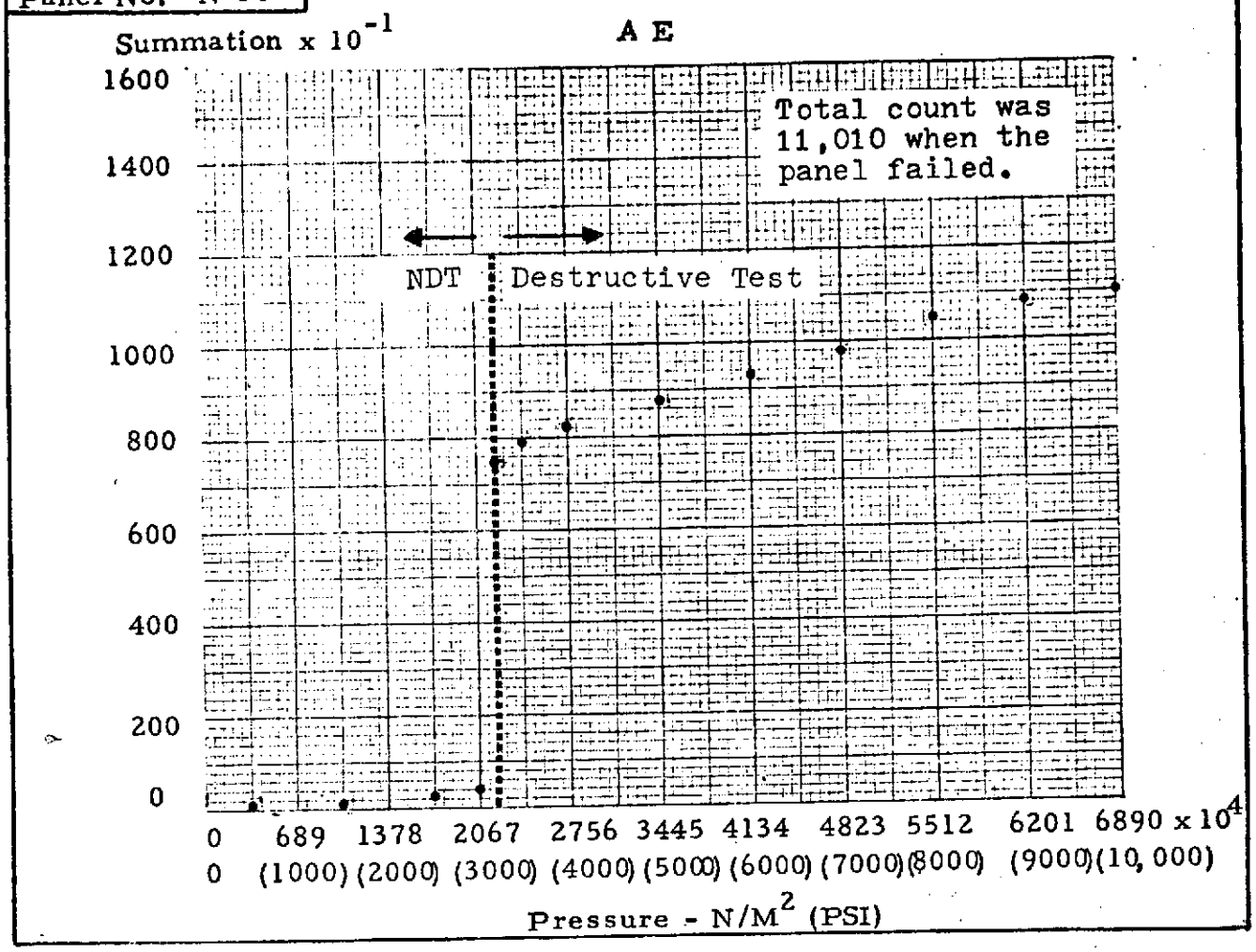
METALLOGRAPHIC ANALYSIS:

Area of slight visable bulge after pressurization. Weak bond has failed. Magnification 50X.

Section showing full bond unfailed. Magnification 50X.

FIGURE C-3

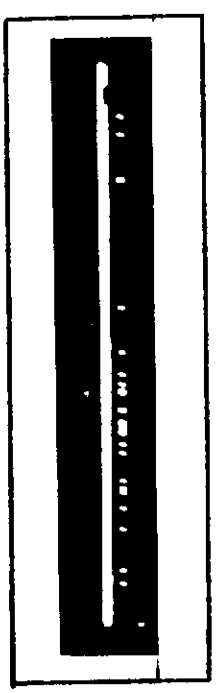
Panel No. N-30



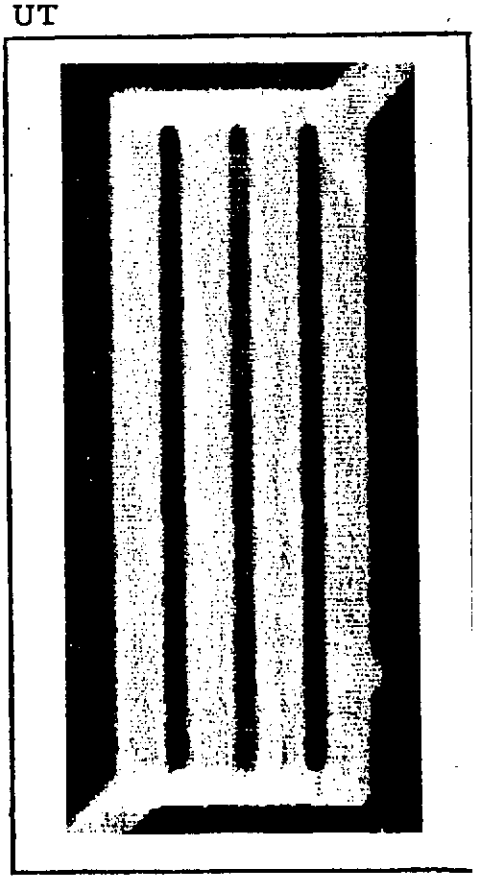
HNDT (Before AE)

Press. - 20.7 x 10^5 N/M^2
(300 PSI)

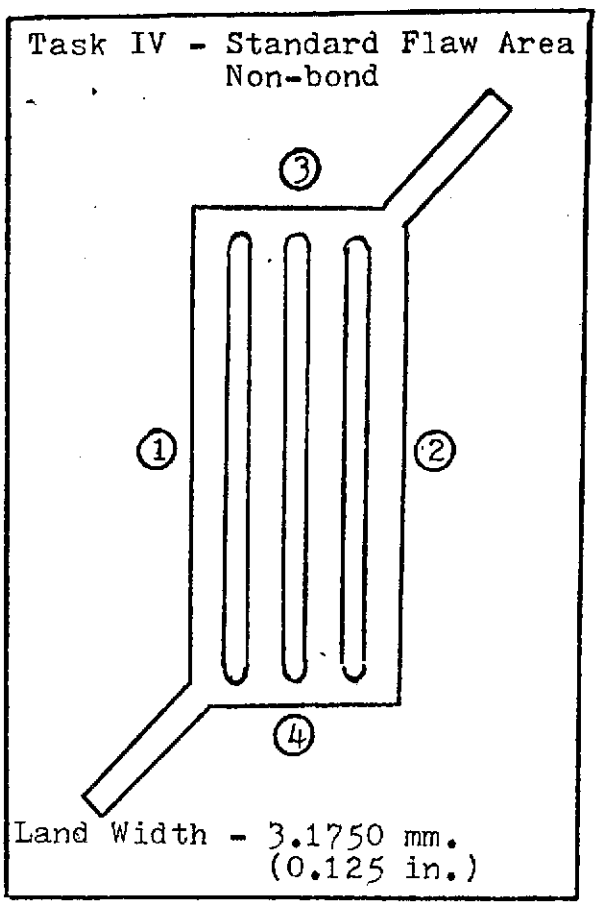
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-38



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.2814	0.2473
②	6.2738	0.2470
③	6.2763	0.2471
④	6.2713	0.2469

COVERPLATE

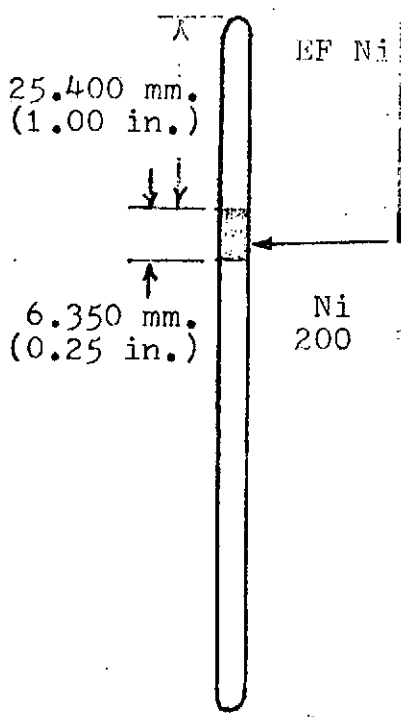
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9220	0.0363
②	0.9195	0.0362
③	0.9398	0.0370
④	0.9550	0.0376

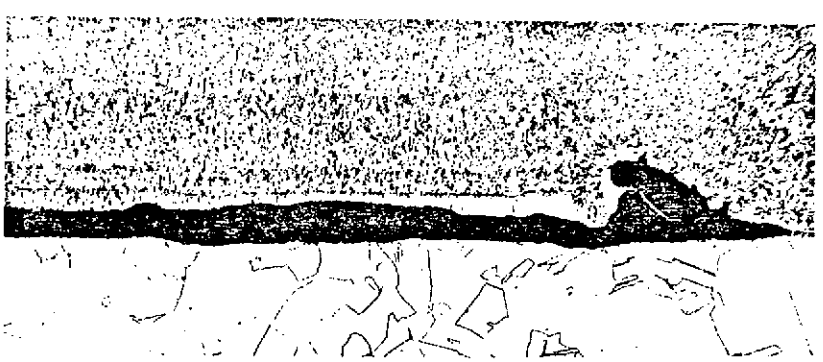
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 3.93×10^7 N/m^2 (5,700 psi)

CENTER LAND DEFECT



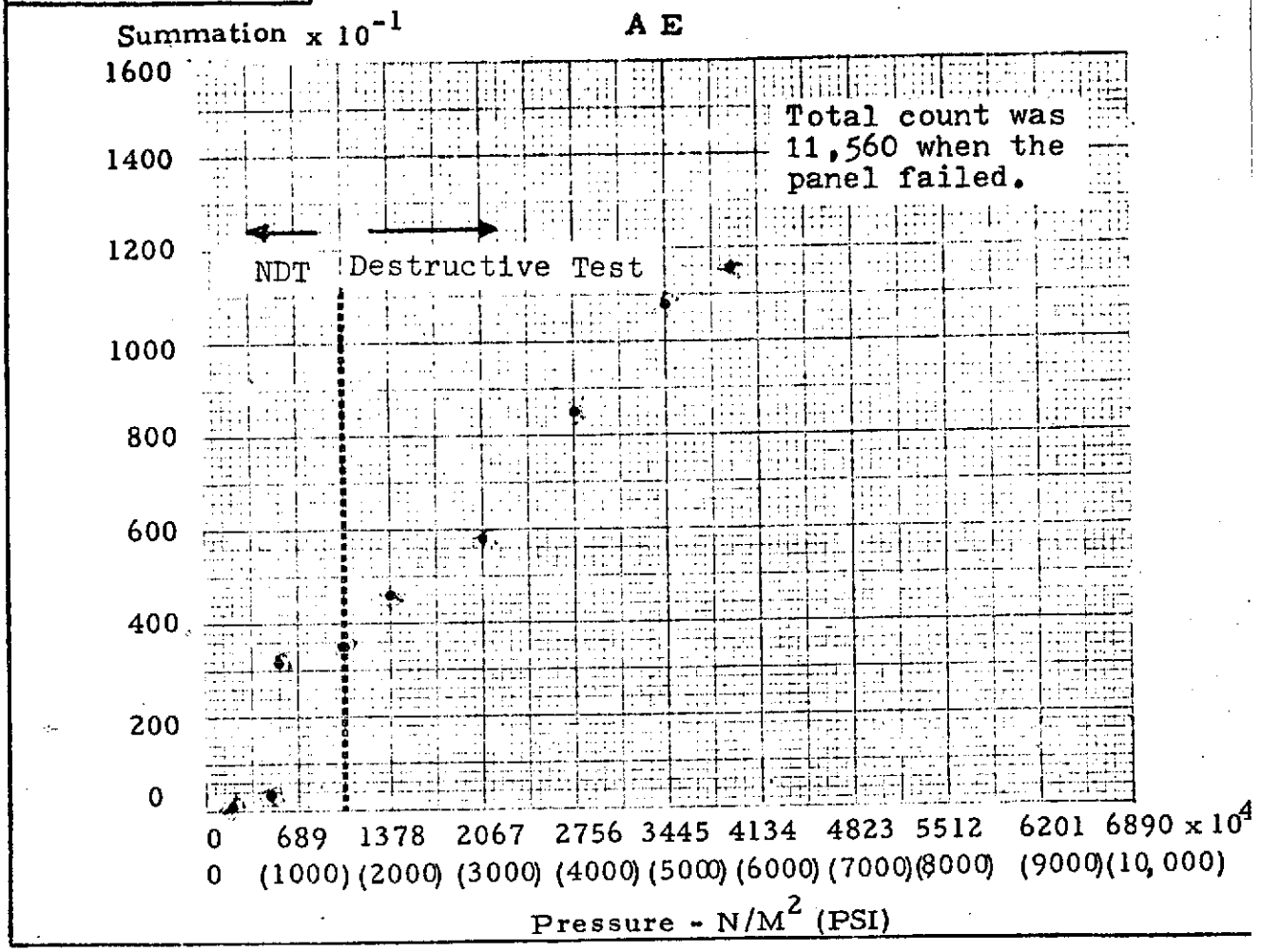
METALLOGRAPHIC ANALYSIS:



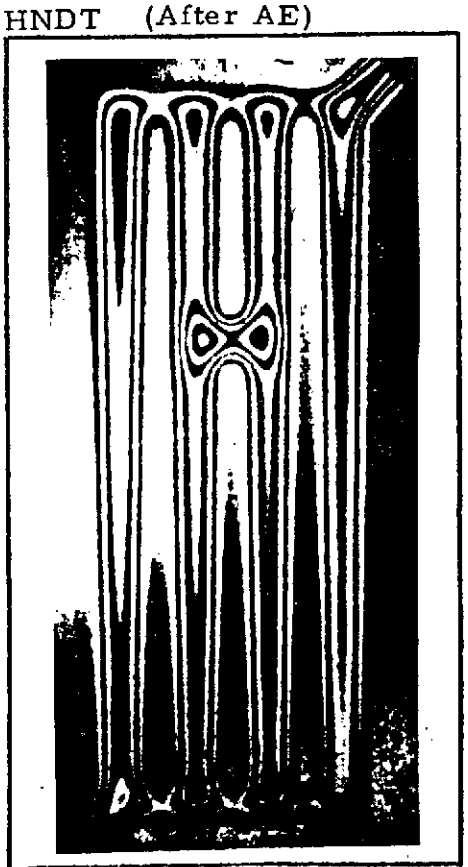
Section showing lower end of planned nonbond. Note failure of tack-bond intentionally produced at the termination of the defect. This held the nonbond in place for subsequent electroforming. Magnification 50X.

FIGURE C-4

Panel No. N-38

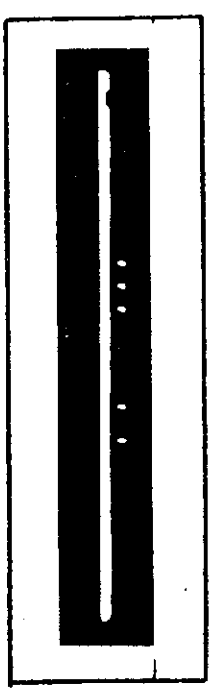


HNDT (After AE)

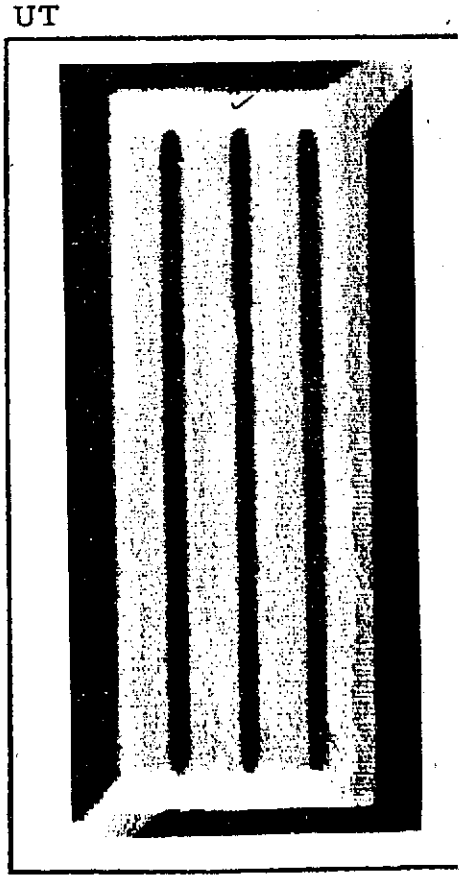


Press. - 13.8 x 10^5 N/M^2
(220 PSI)

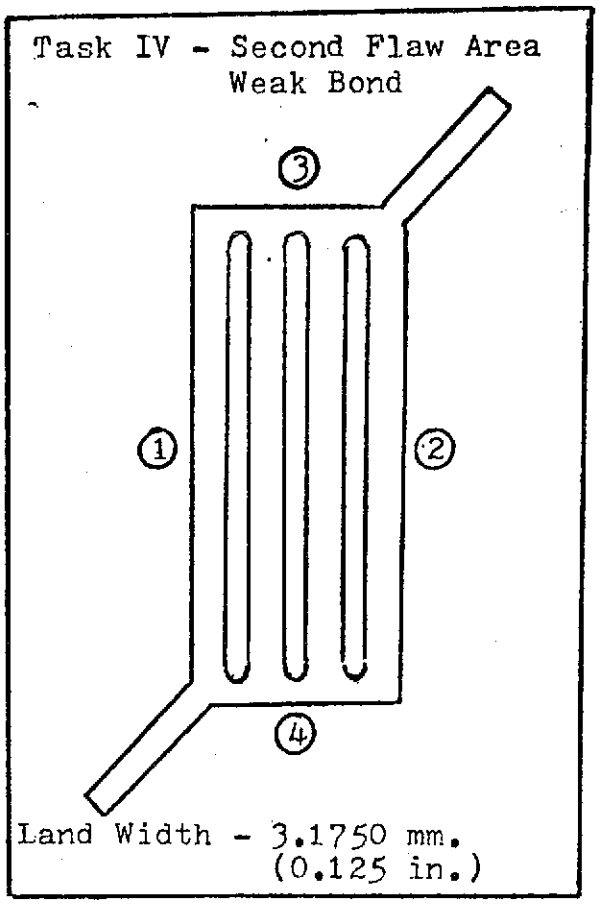
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-31



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.004 in. (0.1016 mm.)

THICKNESS:	MM.	INCHES
①	6.3500	0.2500
②	6.3373	0.2495
③	6.3627	0.2505
④	6.2788	0.2472

COVERPLATE

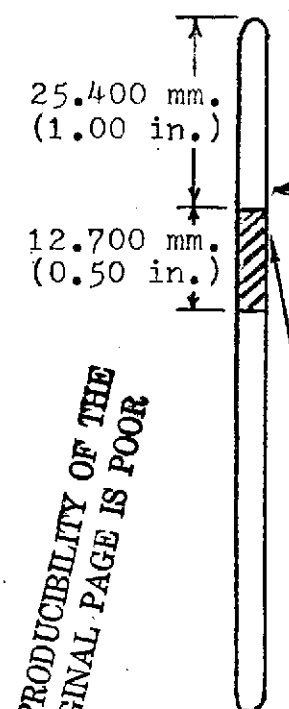
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9474	0.0373
②	1.0008	0.0394
③	0.9881	0.0389
④	1.0693	0.0421

PRESSURE REQUIRED TO FAIL BOND:

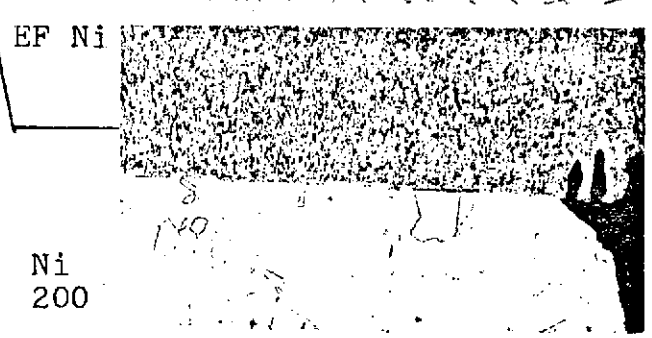
Bond failed at a pressure of 5.87×10^7 N/m^2 (8,500 psi)

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

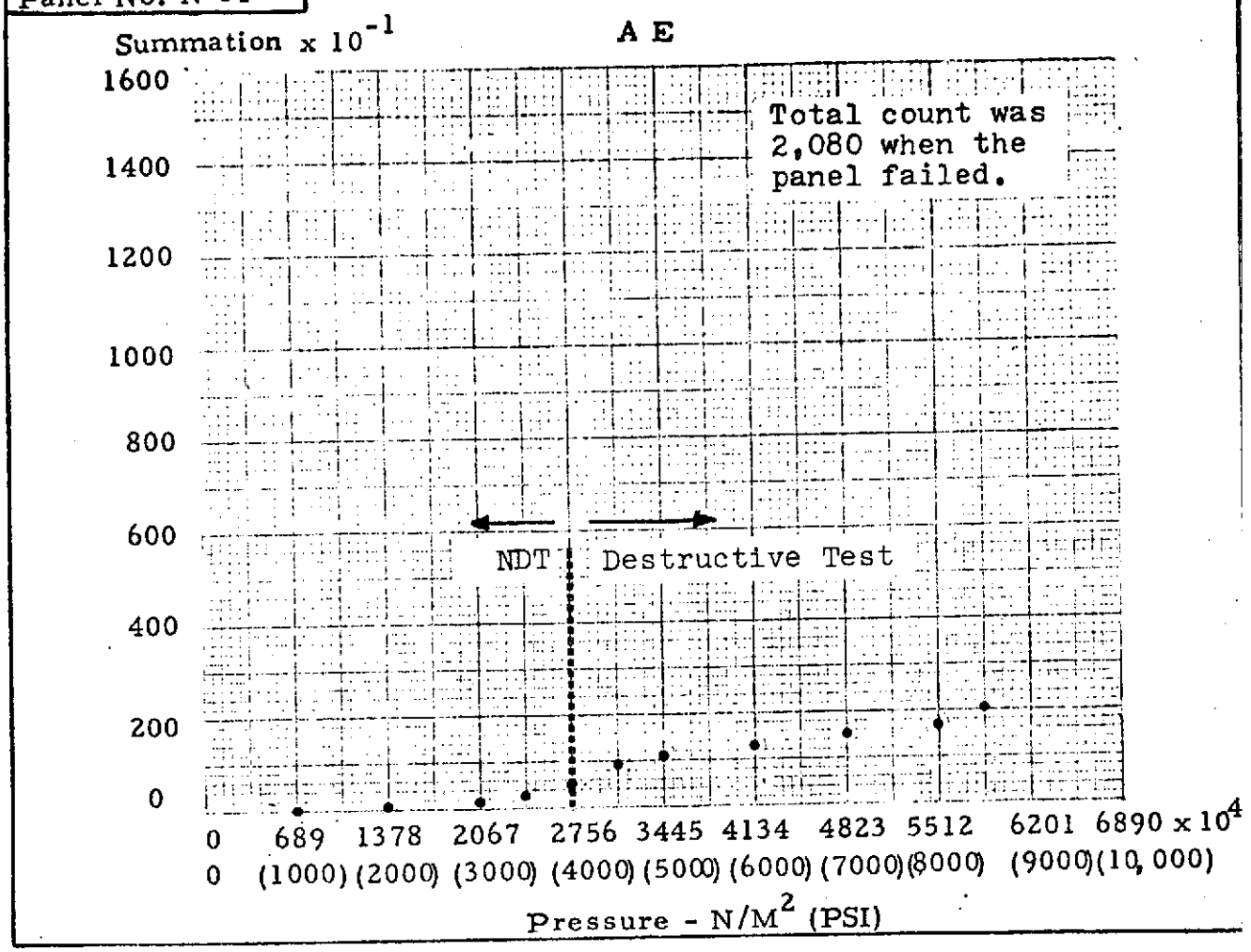
Full bond section. Note tack-bonding on land edge. Failure appeared to start in EF Ni. Magnification 50X.



Weak bond section. Bond failure was initiated at edge of land. Magnification 50X.

FIGURE C-5

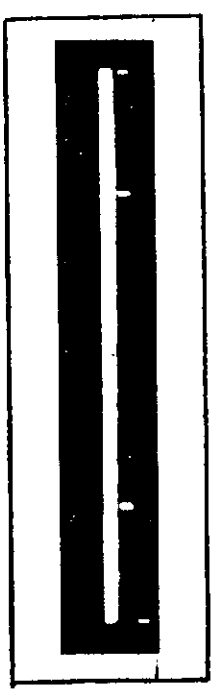
Panel No. N-31



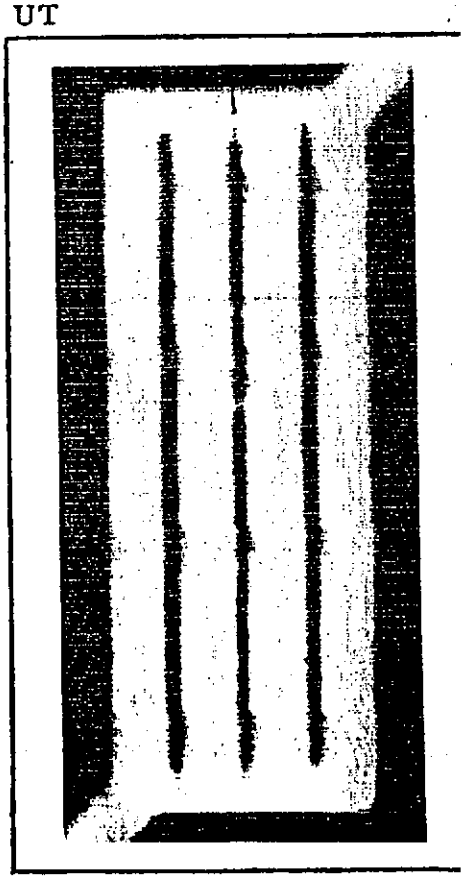
HNDT (After AE)

Press. 20.7 x 10^5 N/M^2 (300 PSI)

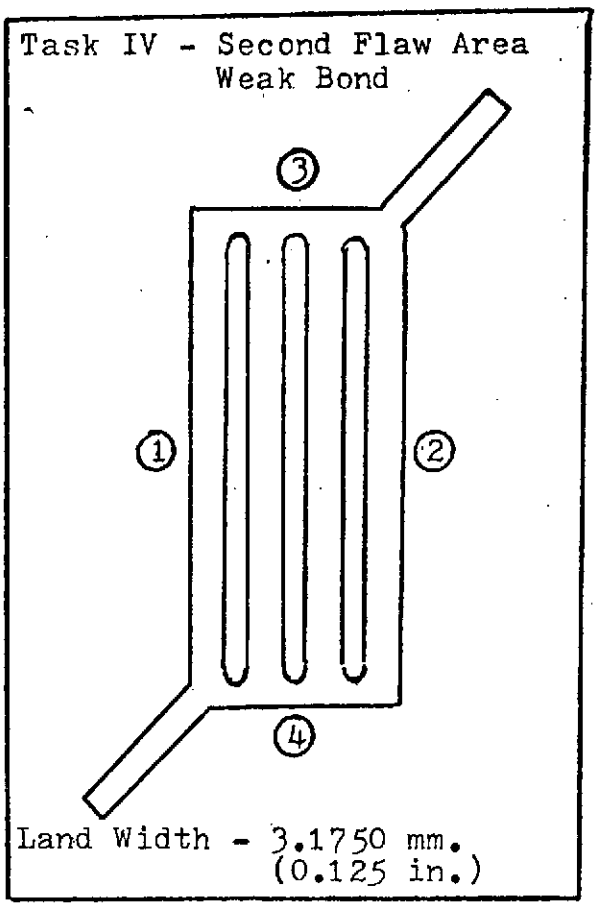
AE FLAW LOCATOR CENTER LAND



UT



ELECTROFORMED PANEL NO. N-32



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.0015 in. (0.0381 mm.)

THICKNESS:	MM.	INCHES
①	6.3830	0.2513
②	6.3932	0.2517
③	6.3754	0.2510
④	6.3271	0.2491

COVERPLATE

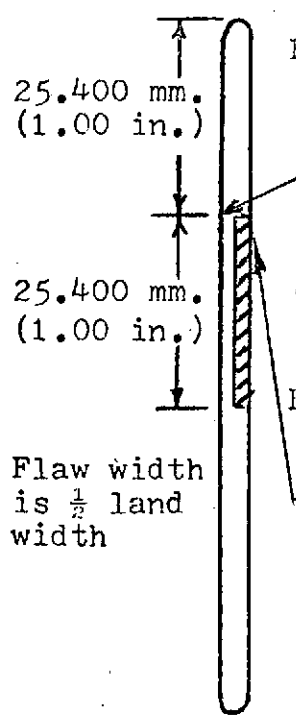
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9754	0.0384
②	0.9550	0.0376
③	0.9576	0.0377
④	0.9982	0.0393

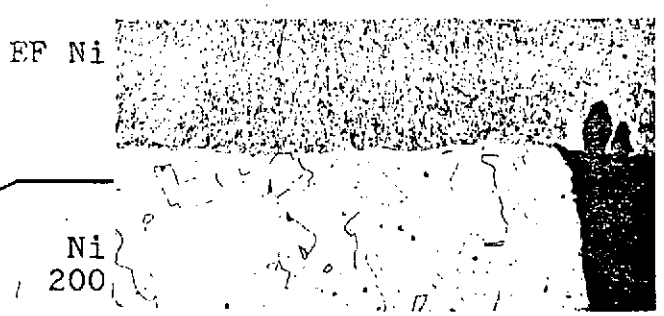
PRESSURE REQUIRED TO FAIL BOND:

Panel withstood a pressure of 6.9×10^7 N/m^2 (10,000 psi). Channel buckling was initiated.

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

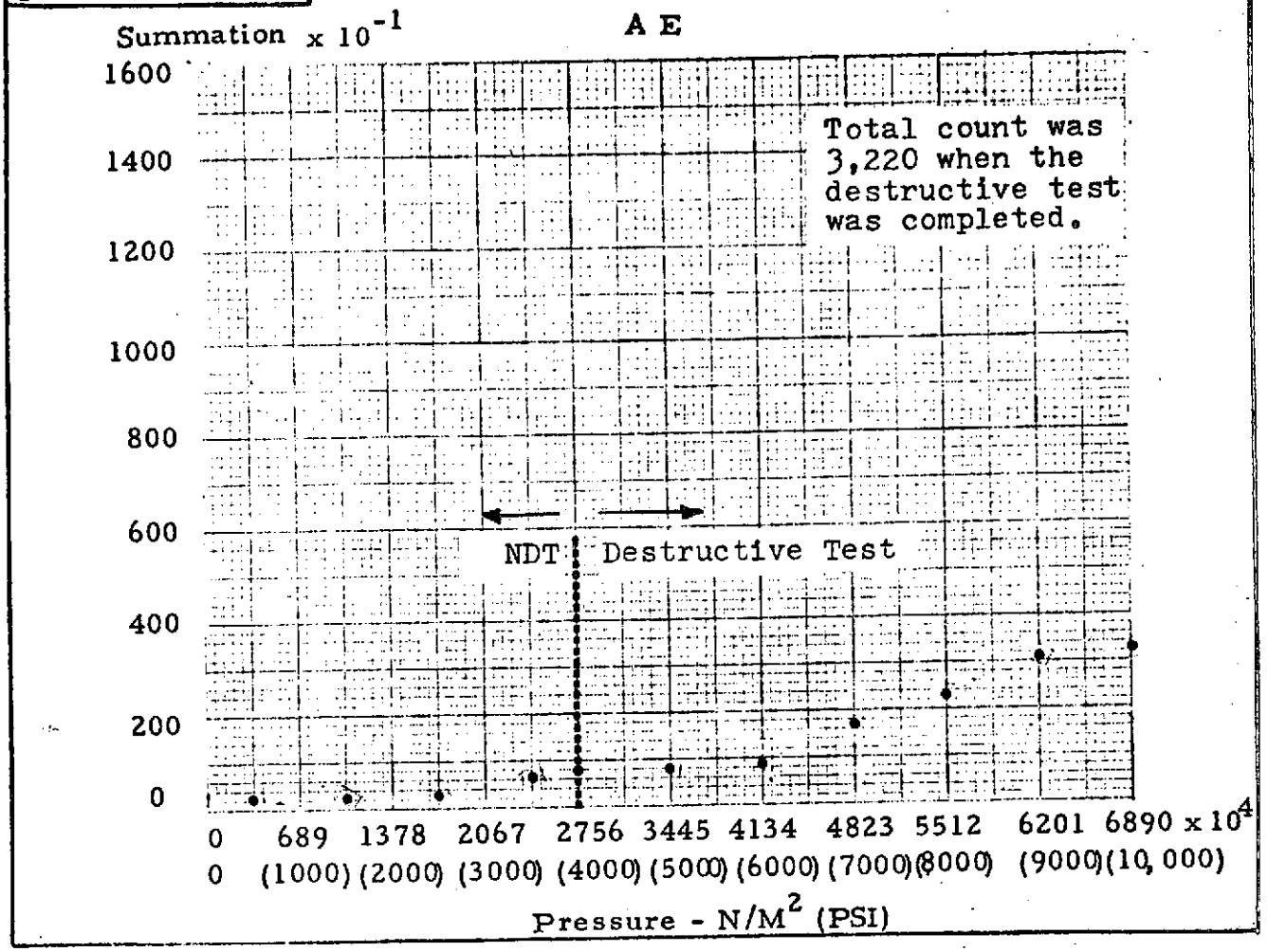


Full bond section. Some failure was initiated at land edge. Magnification 50X.

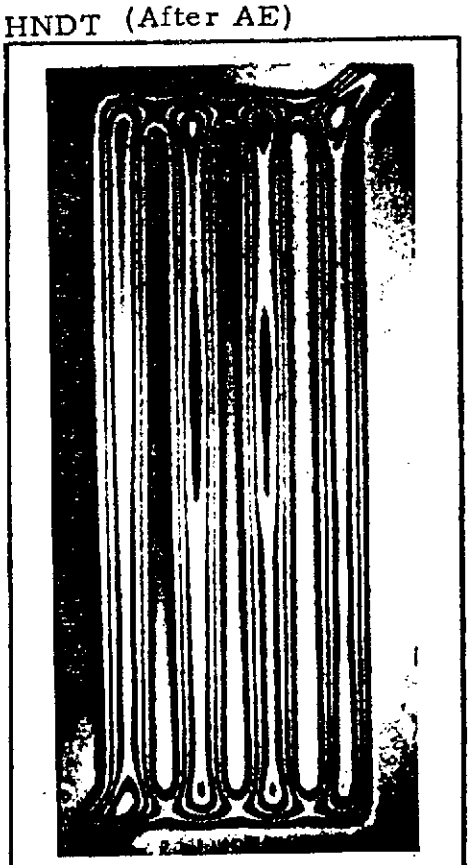
Planned defect area. No bond failure is indicated. Some intermittent failure may have occurred. Magnification 50X.

FIGURE C-6

Panel No. N-32

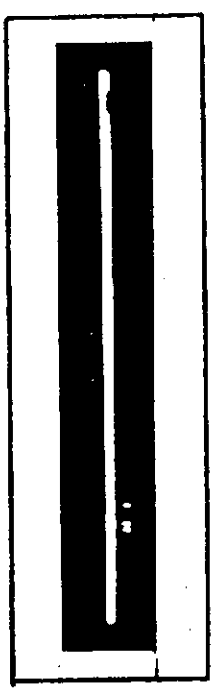


HNDT (After AE)

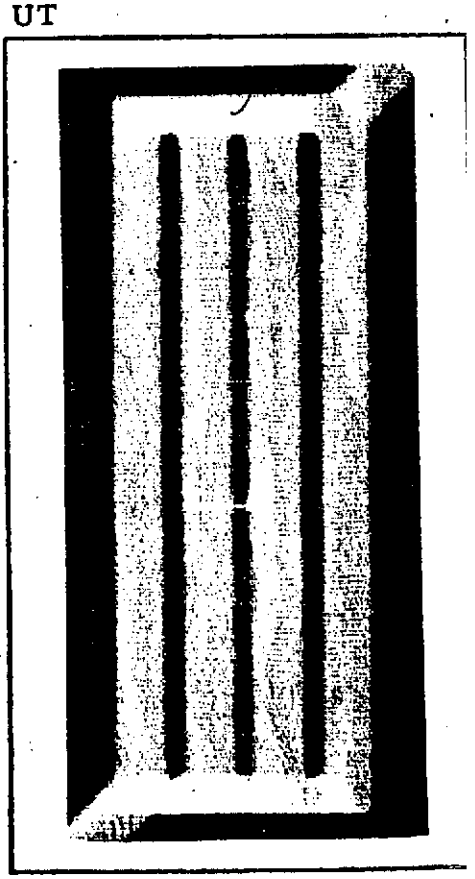


Press. 20.7 x 10^5 N/M^2
(300 PSI)

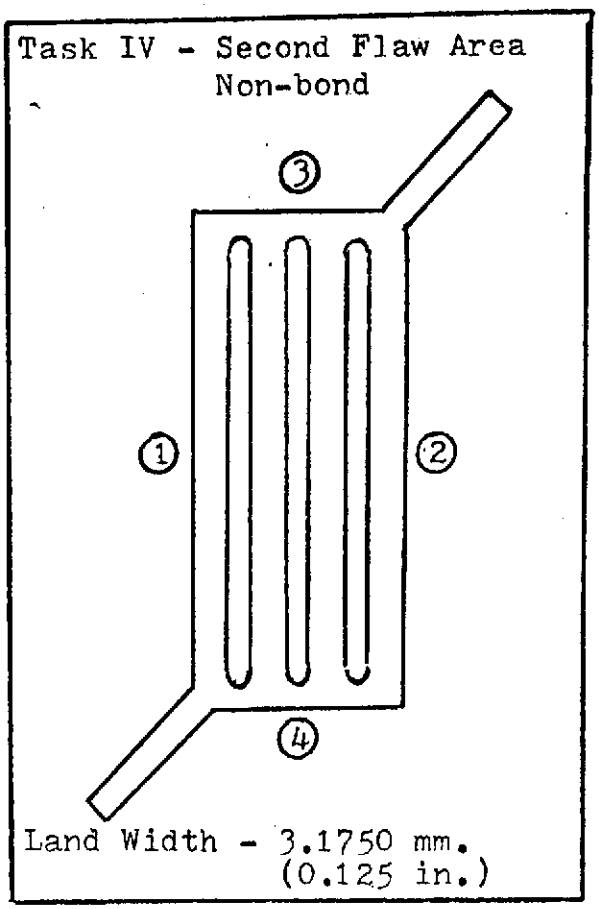
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-39



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.2788	0.2472
②	6.2713	0.2469
③	6.2662	0.2467
④	6.2636	0.2466

COVERPLATE

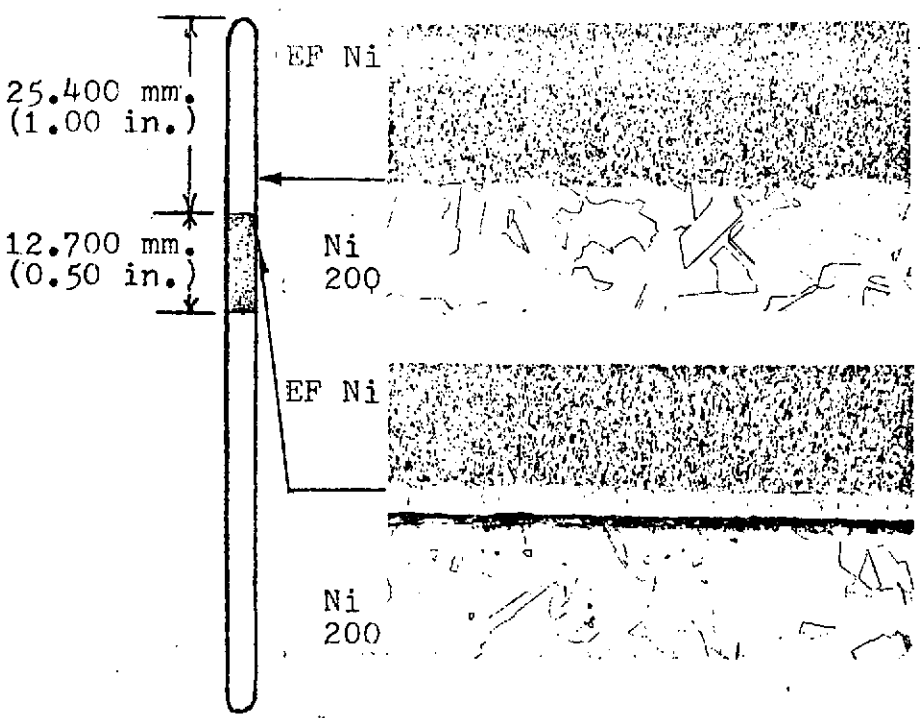
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.8534	0.0336
②	0.8865	0.0349
③	0.9957	0.0392
④	0.9754	0.0384

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 1.66×10^7 N/m^2 (2,400 psi)

CENTER LAND DEFECT



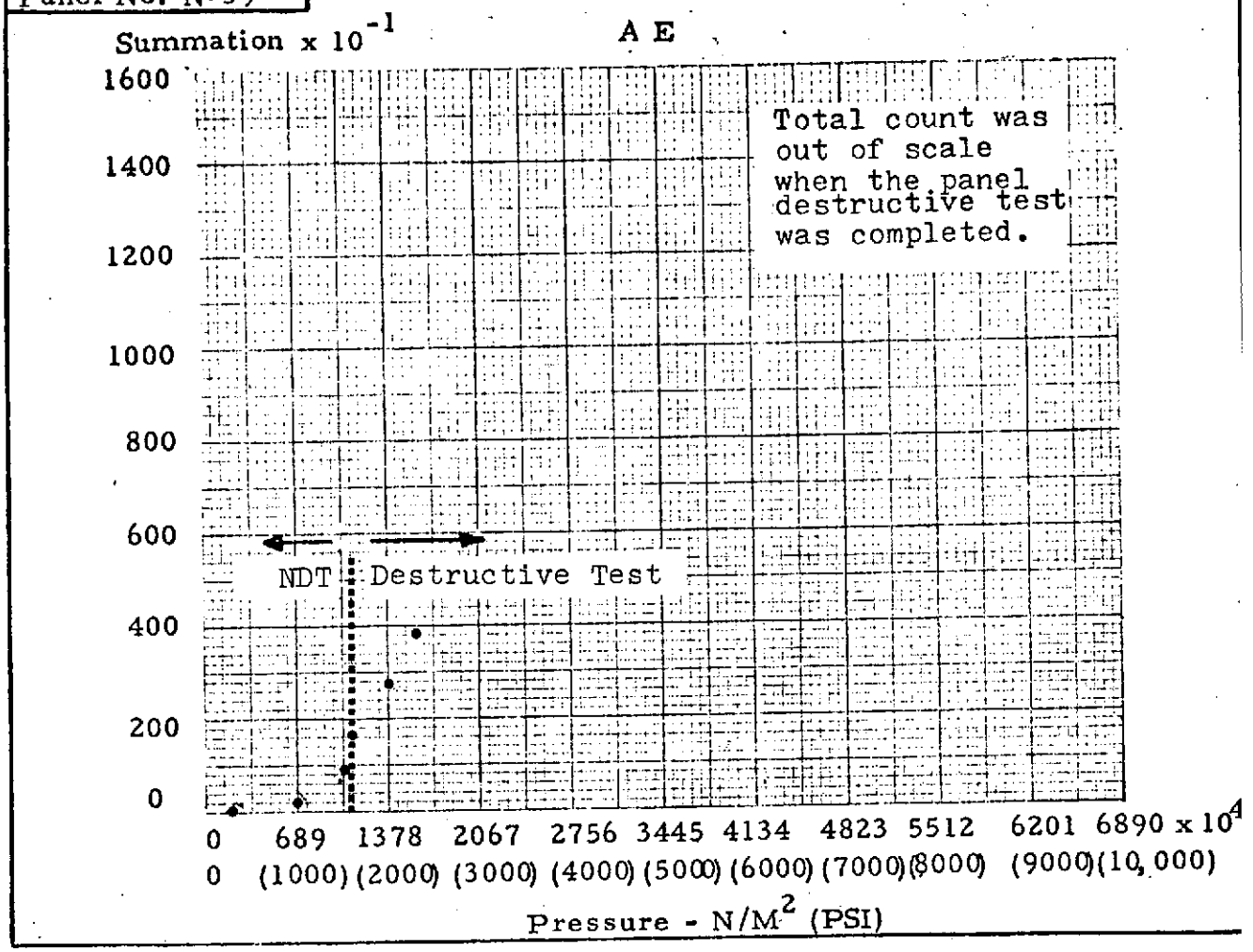
METALLOGRAPHIC ANALYSIS:

Full bond section. No failure is noted. Magnification 50X.

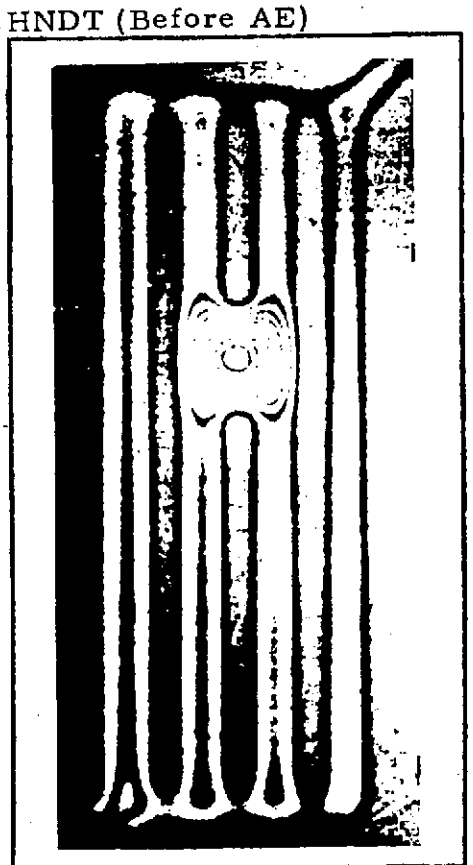
Nonbond planned defect. Layer above nonbond is initial electrodeposit which was followed by a plating stop. Magnification 50X. Some very weak bonding is indicated by the slight metal disturbance.

FIGURE C-7

Panel No. N-39

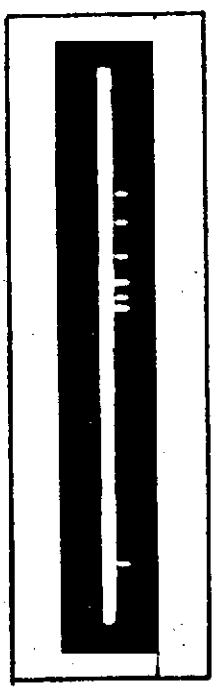


HNDT (Before AE)

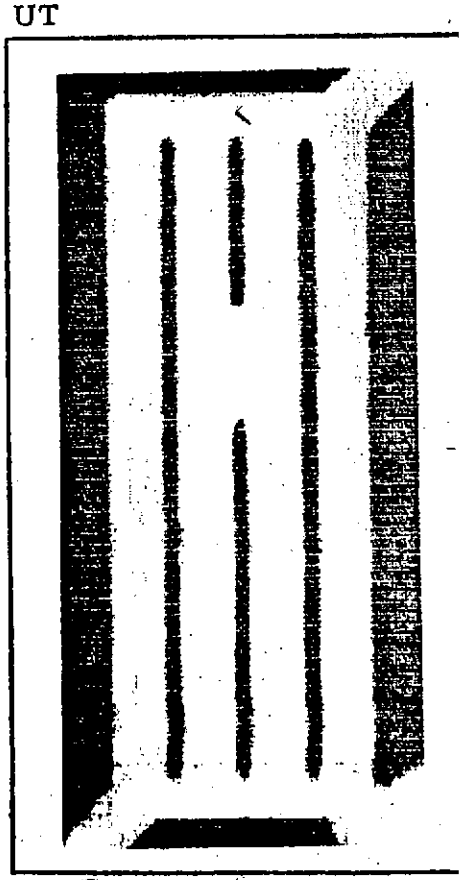


Press. - 5.2×10^5 N/M^2
(75 PSI)

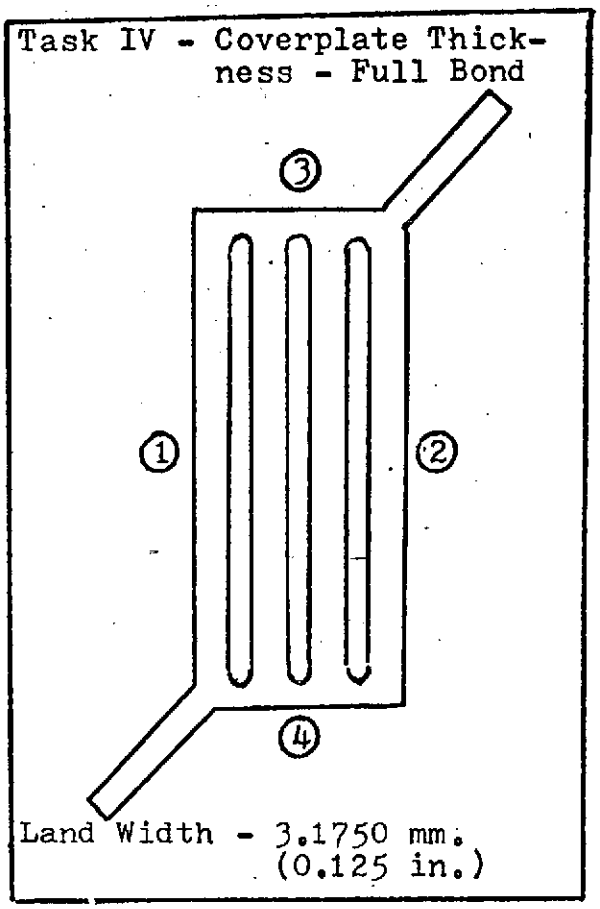
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-09 "A"



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.0655	0.2388
②	6.1087	0.2405
③	6.0630	0.2387
④	6.0909	0.2398

COVERPLATE

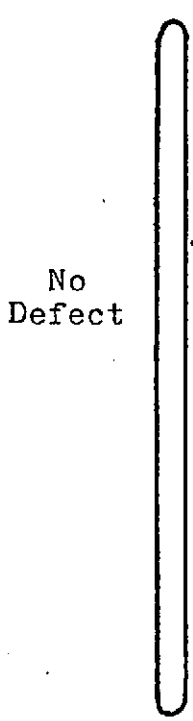
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.7595	0.0299
②	0.7087	0.0279
③	0.7036	0.0277
④	0.6502	0.0256

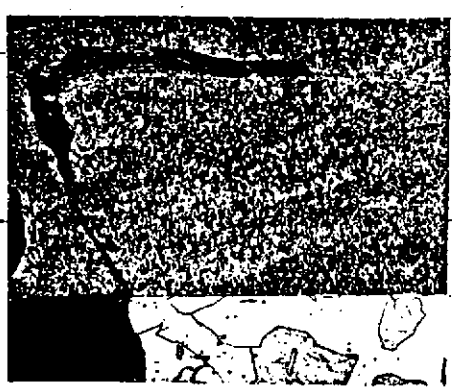
PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 5.31×10^7 N/m^2 (7,700 psi).

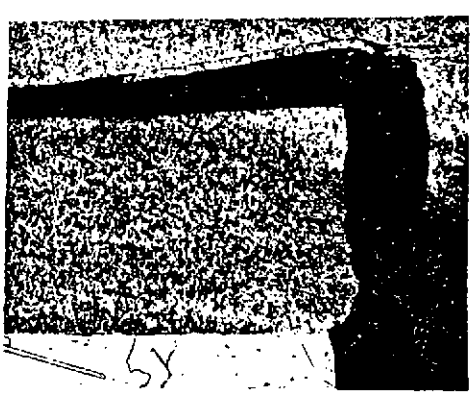
CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



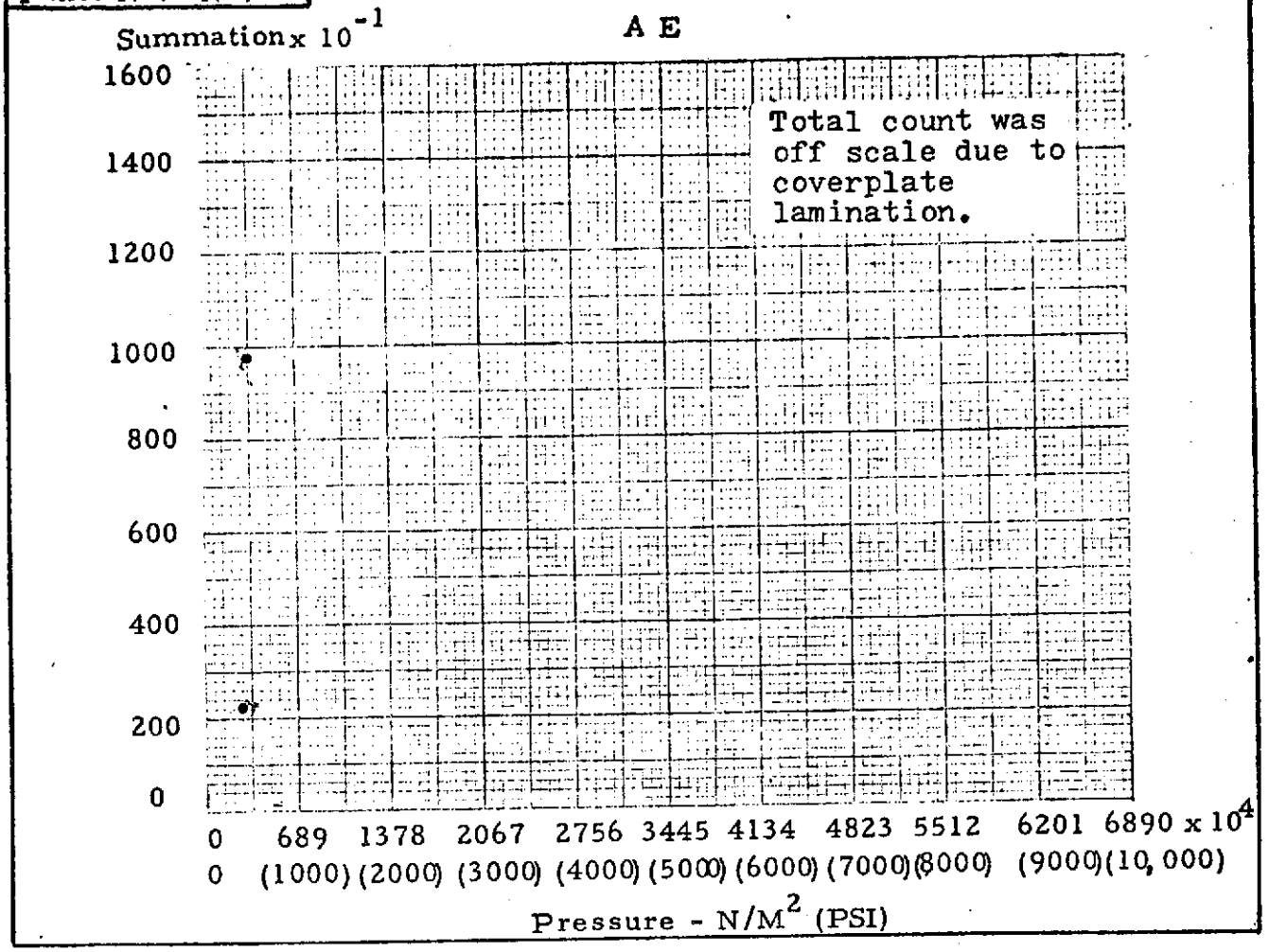
Section showing full bond area. No bond failure occurred. Panel failed by rupture of the coverplate. Magnification 50X.



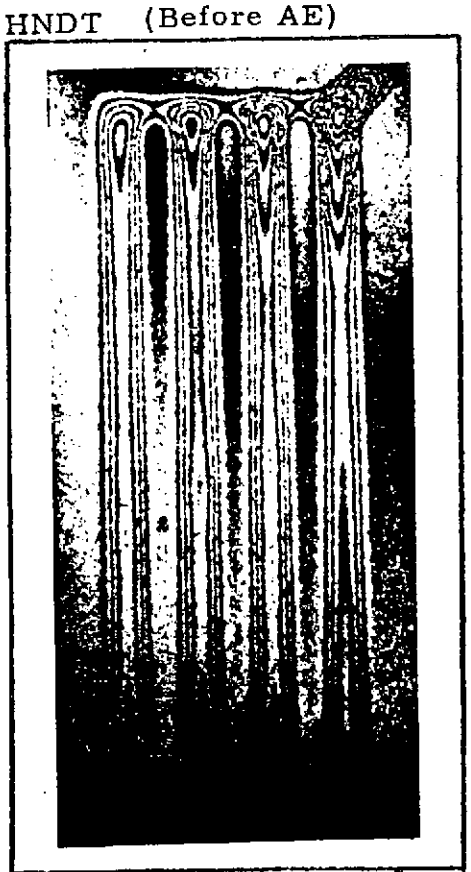
Section showing coverplate failure in the area of Land 3 and next to the area shown in the photo to the left. Magnification 50X. The failure propagated along a plating restart.

FIGURE C-8

Panel No. N-9"A"



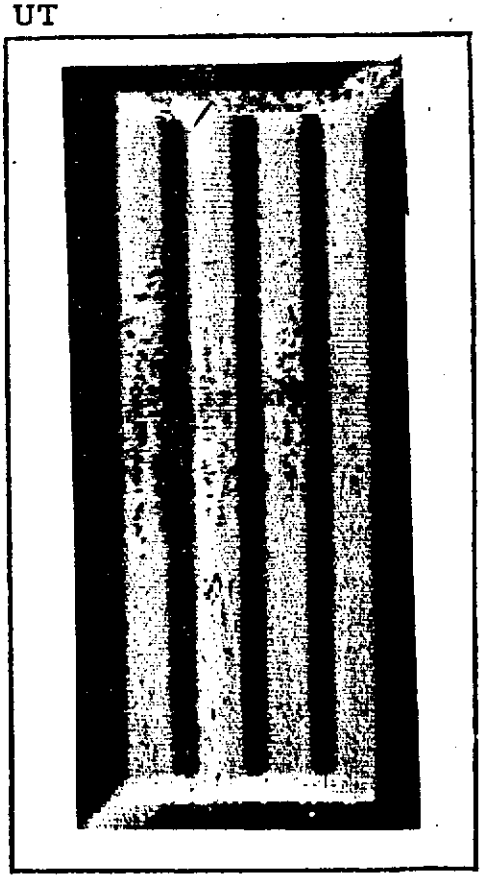
HNDT (Before AE)



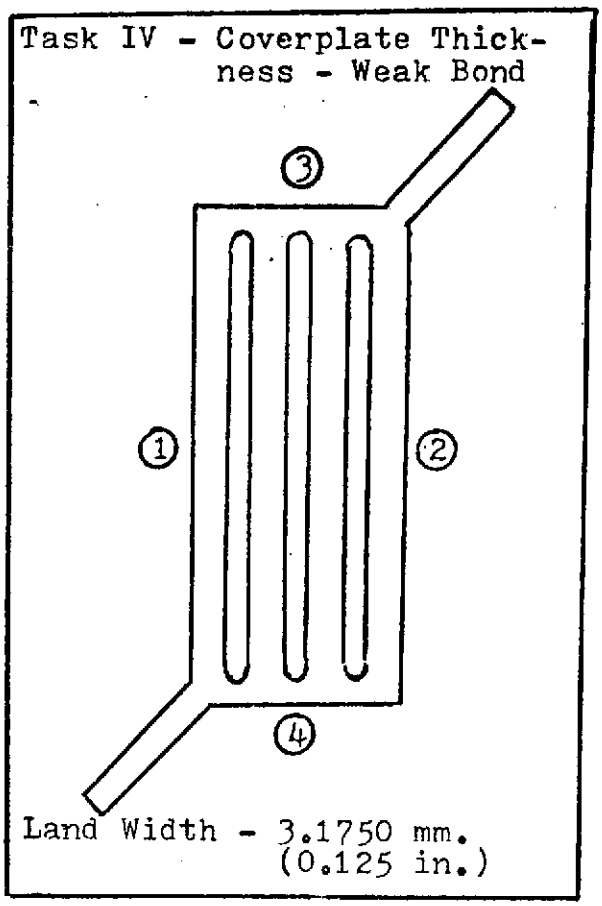
Press. 13.8 x 10^5 N/M^2
(200 PSI)

AE
FLAW LOCATOR
CENTER LAND

UT



ELECTROFORMED PANEL NO. N-33



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.004 in. (0.1016 mm.)

THICKNESS:	MM.	INCHES
①	6.2535	0.2462
②	6.2840	0.2474
③	6.2788	0.2472
④	6.2788	0.2472

COVERPLATE

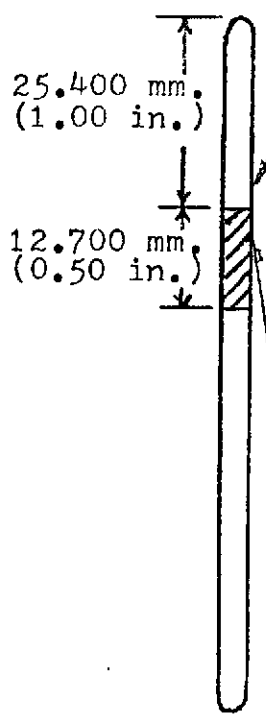
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.7493	0.0295
②	0.6960	0.0274
③	0.6629	0.0261
④	0.7061	0.0278

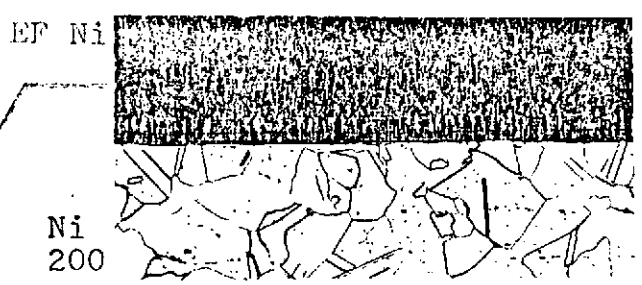
PRESSURE REQUIRED TO FAIL BOND:

Bond failure occurred at a pressure of 4.62×10^7 N/m^2 (6,700 psi). Bond failure was intermittent.

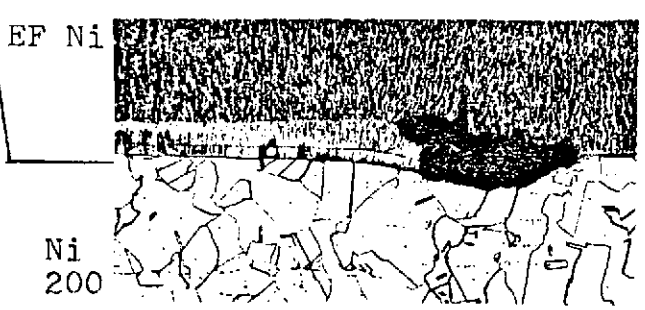
CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



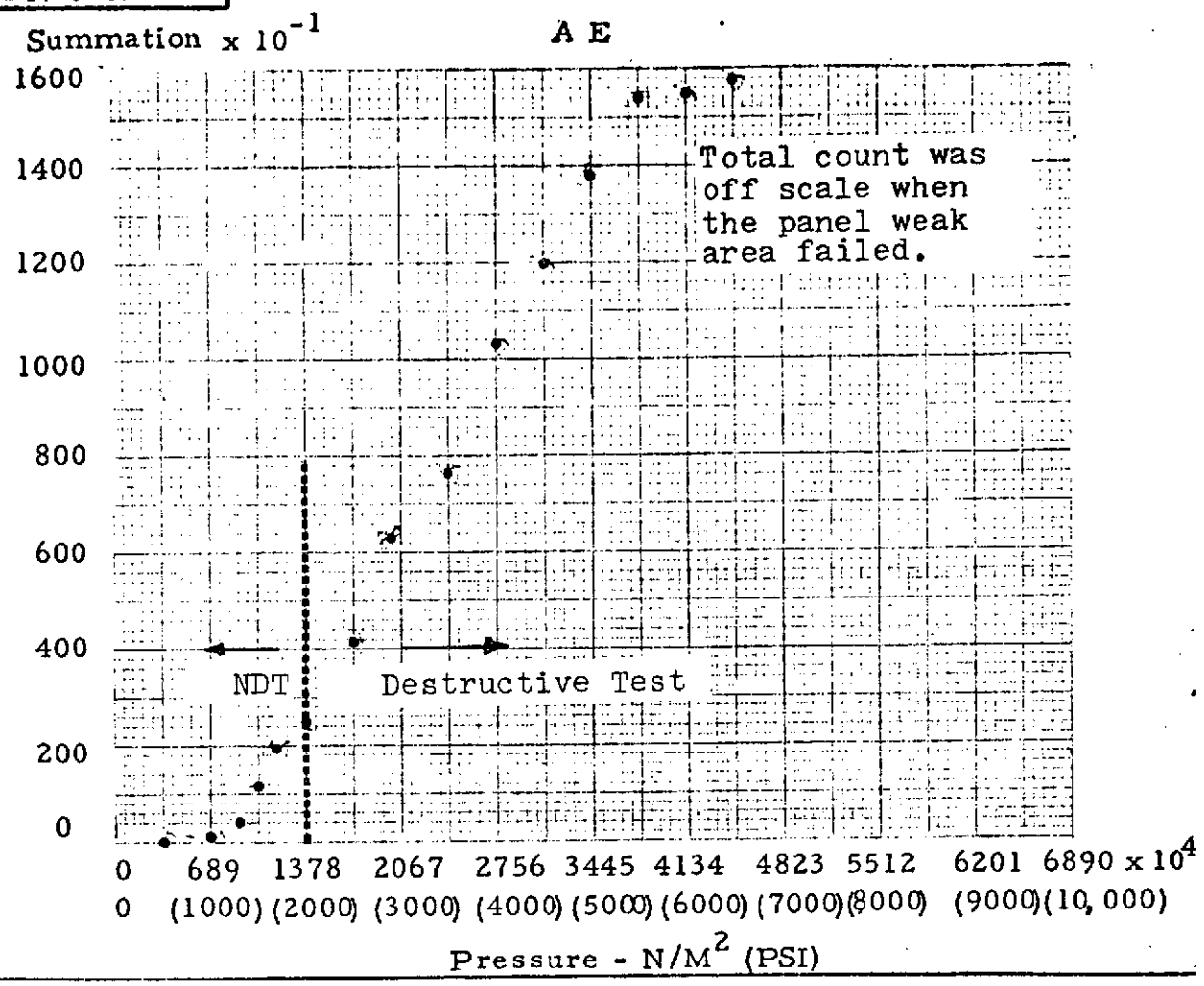
Section of full bond adjacent to the planned weak bond. Magnification 50X.



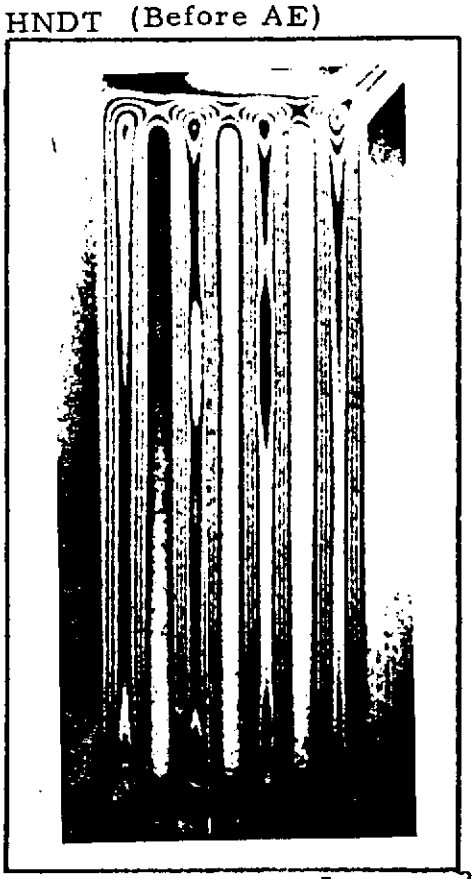
Section of the planned weak bond showing regions of partial failure. Magnification 50X.

FIGURE C-9

Panel No. N-33

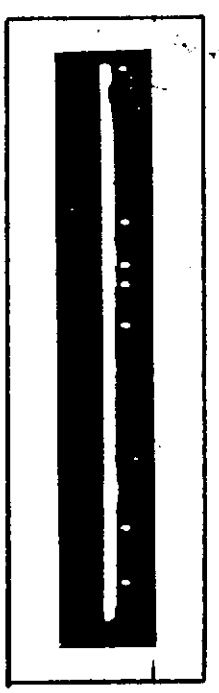


HNDT (Before AE)

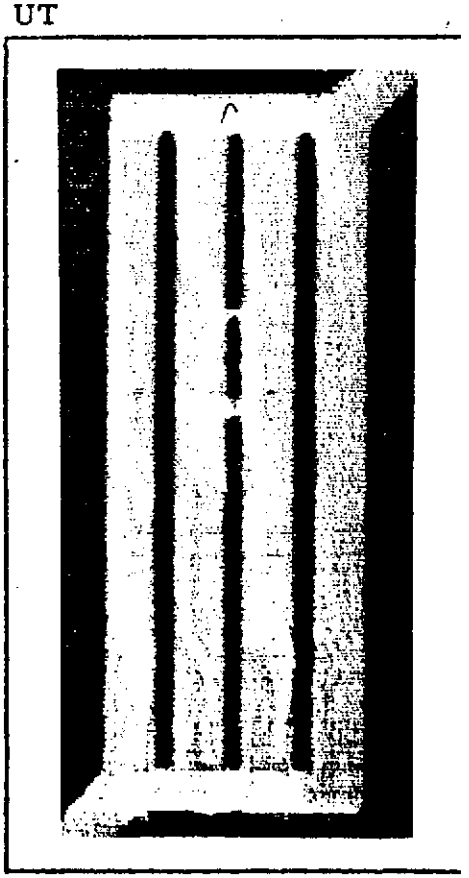


Press. - 13.8 x 10^5 N/M^2
(200 PSI)

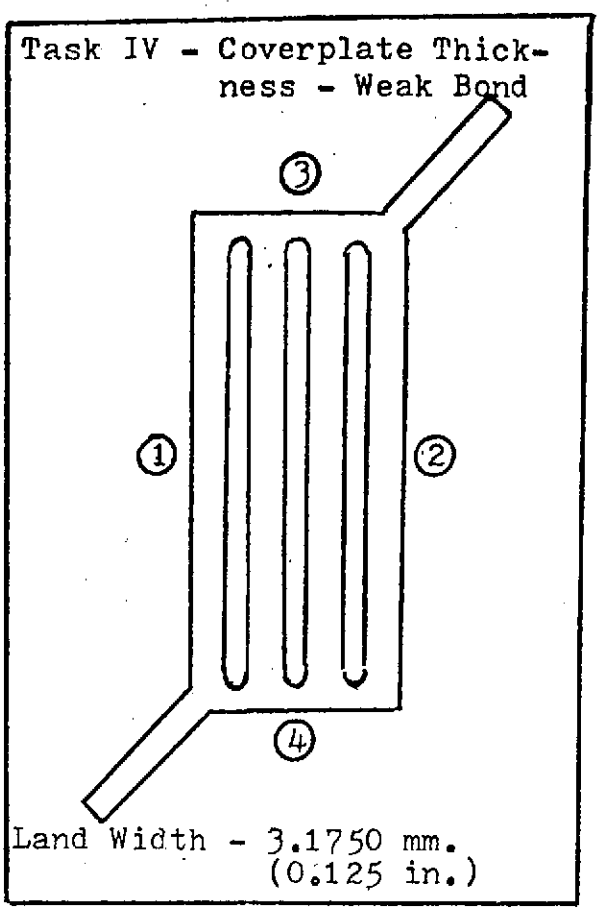
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-34 "A"



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.1265	0.2412
②	6.1925	0.2438
③	6.1798	0.2433
④	6.1900	0.2437

COVERPLATE

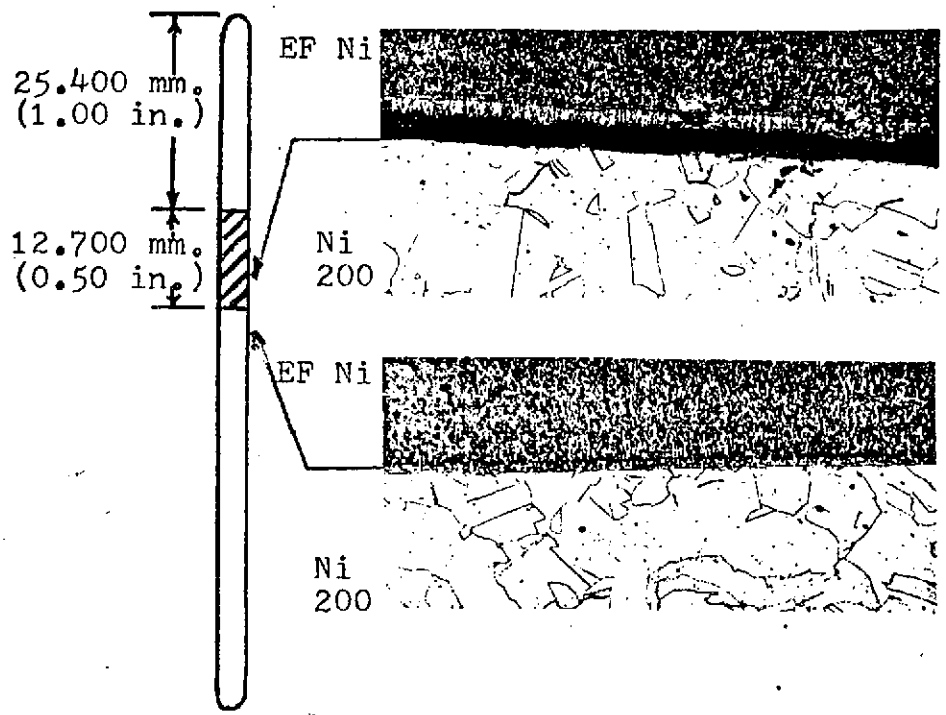
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.7569	0.0298
②	0.7188	0.0283
③	0.6502	0.0256
④	0.7010	0.0276

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.42×10^7 N/m^2 (3,500 psi).

CENTER LAND DEFECT



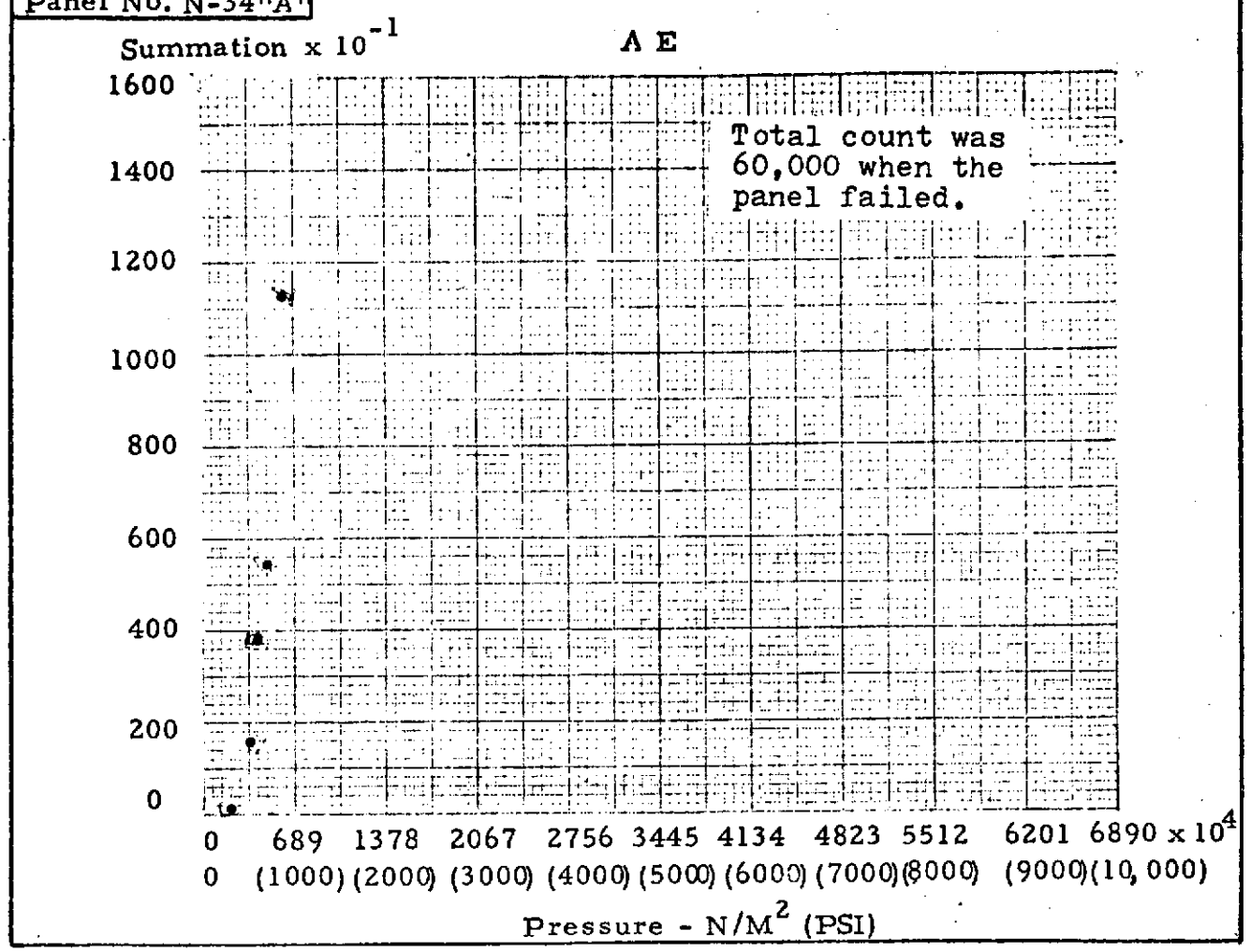
METALLOGRAPHIC ANALYSIS:

Section showing planned weak bond failure. Bond was quite weak as evident from the lack of significant metal disturbance. Magnification 50X.

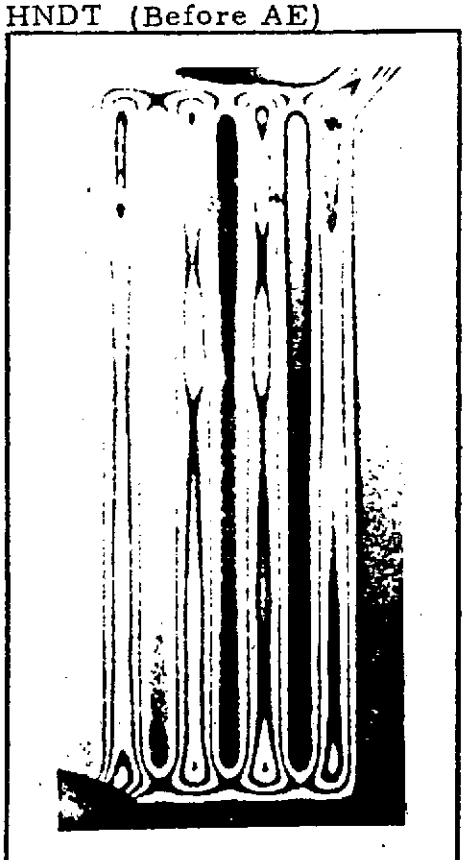
Planned full bond region near the weak bond above. No failure evident. Magnification 50X.

FIGURE C-10

Panel No. N-34"A"

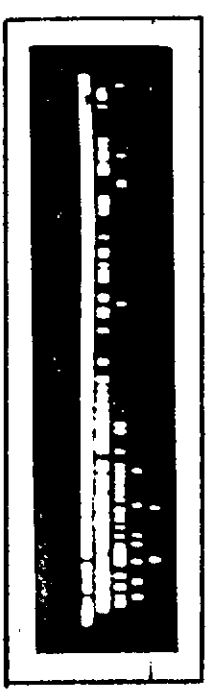


HNDT (Before AE)

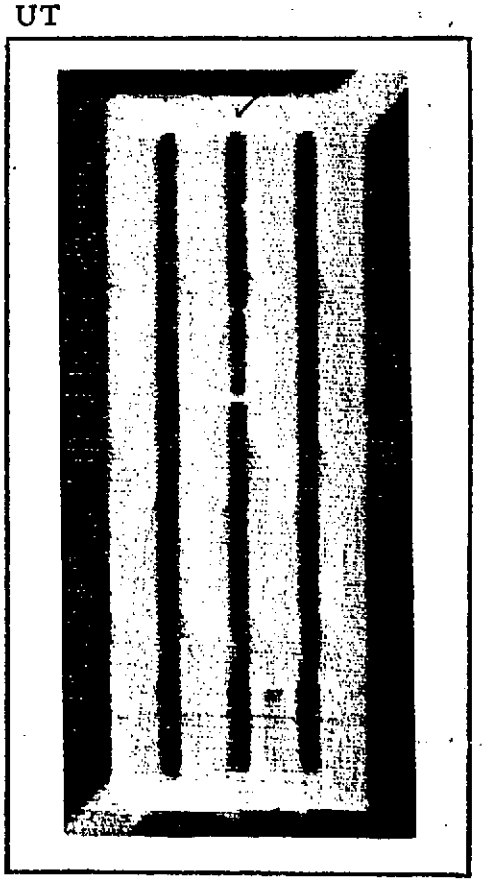


Press. 6.9 x 10^5 N/M^2
(100 PSI)

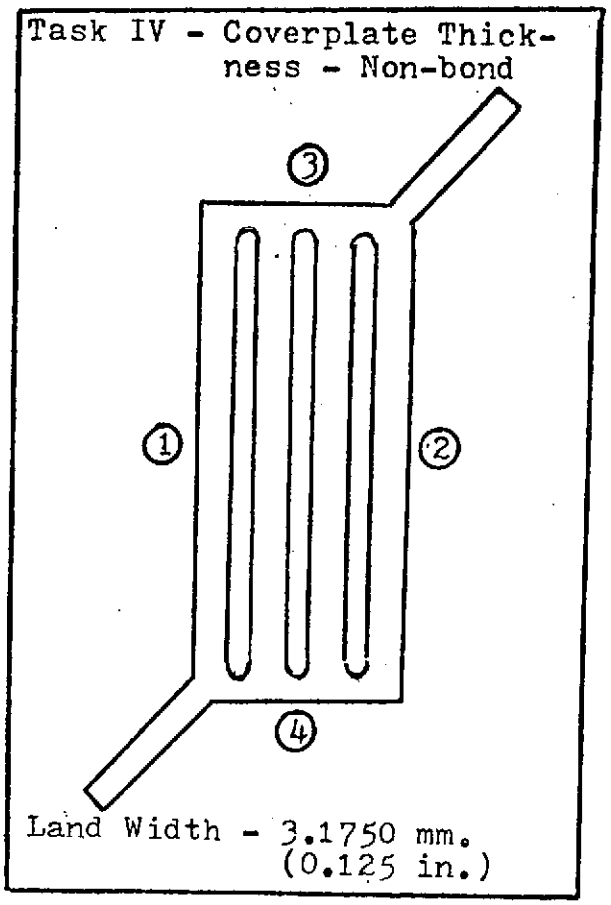
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-40 "A"



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.0085 in. (0.2159 mm.)

THICKNESS:	MM.	INCHES
①	5.9665	0.2349
②	5.9639	0.2348
③	6.0884	0.2397
④	6.0401	0.2378

COVERPLATE

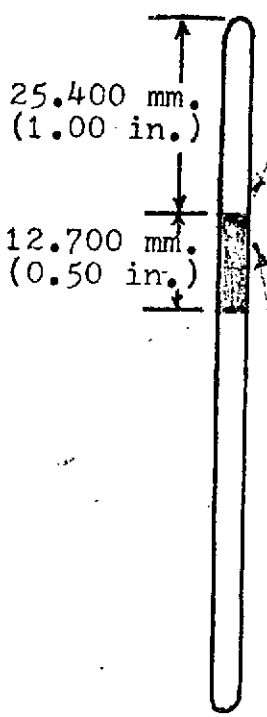
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.7518	0.0296
②	0.7341	0.0289
③	0.6248	0.0246
④	0.7442	0.0293

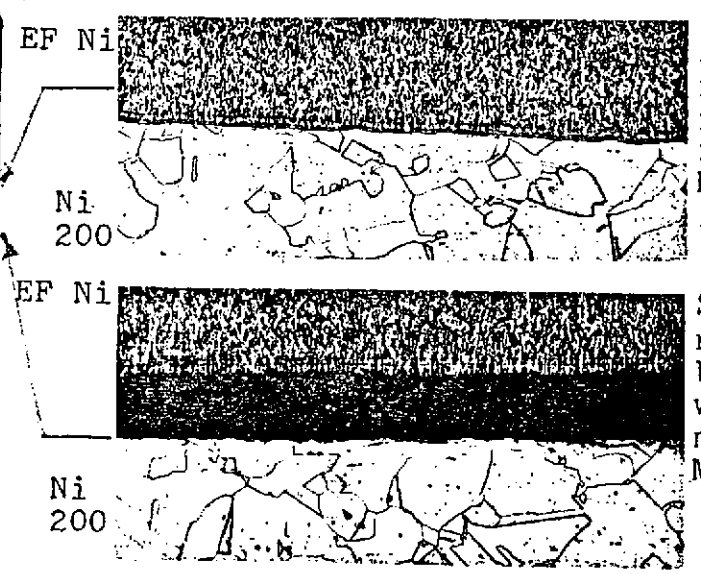
PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 2.42×10^7 N/m^2 (3,500 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

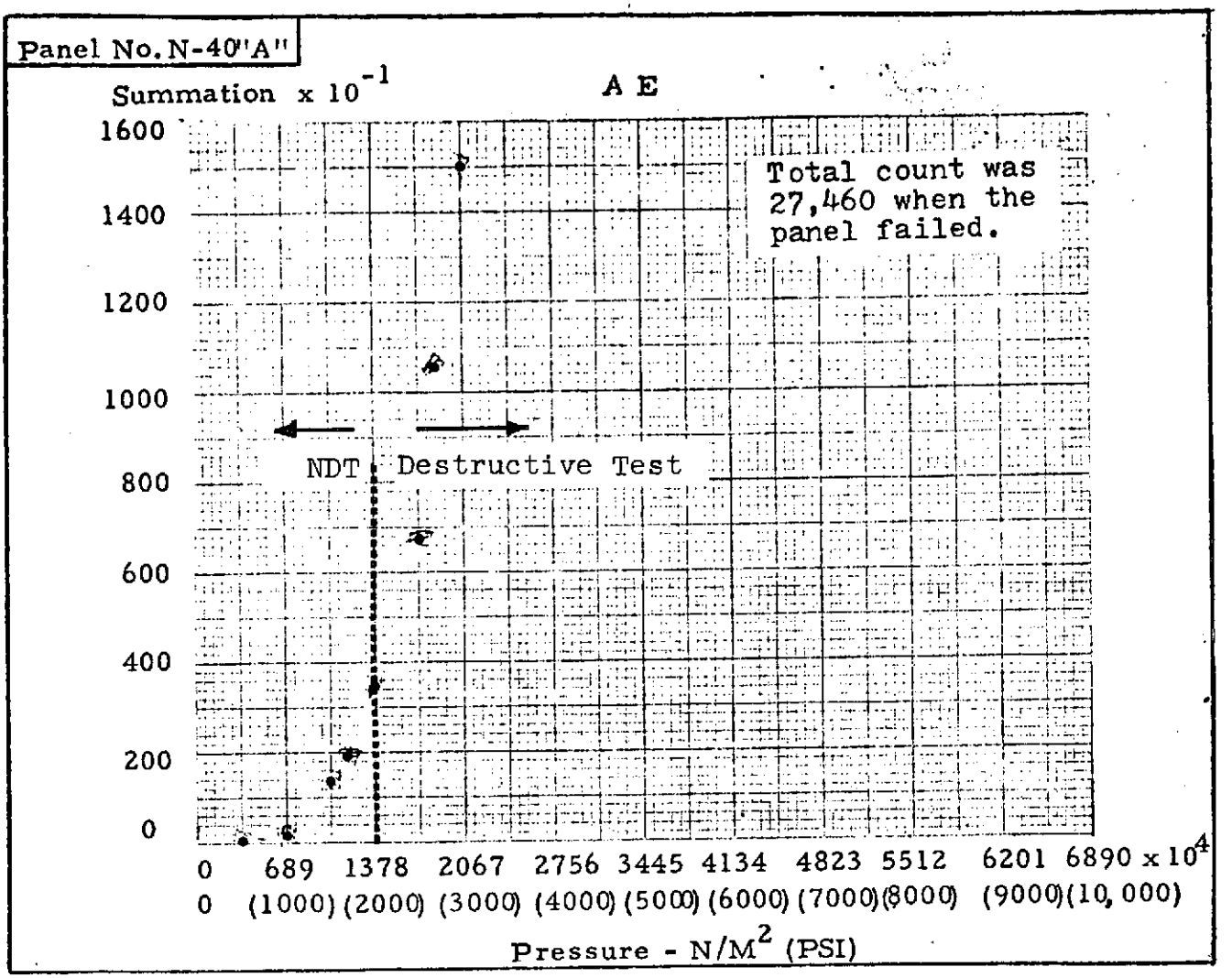


Full bond region next to the planned nonbond. No bond failure evident. Magnification 50X.

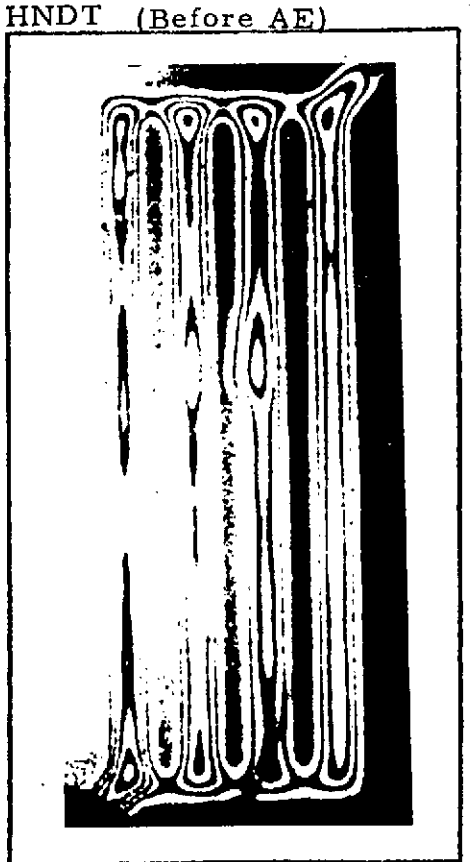
Section of planned nonbond showing bondline separation with little, or no, metal disturbance. Magnification 50X.

FIGURE C-11

Panel No. N-40"A"

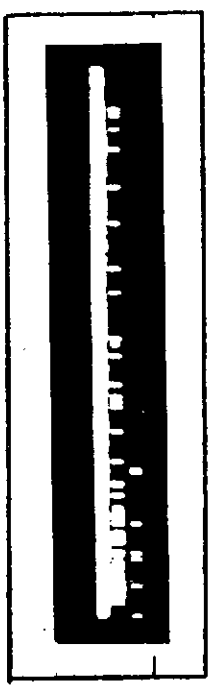


HNDT (Before AE)

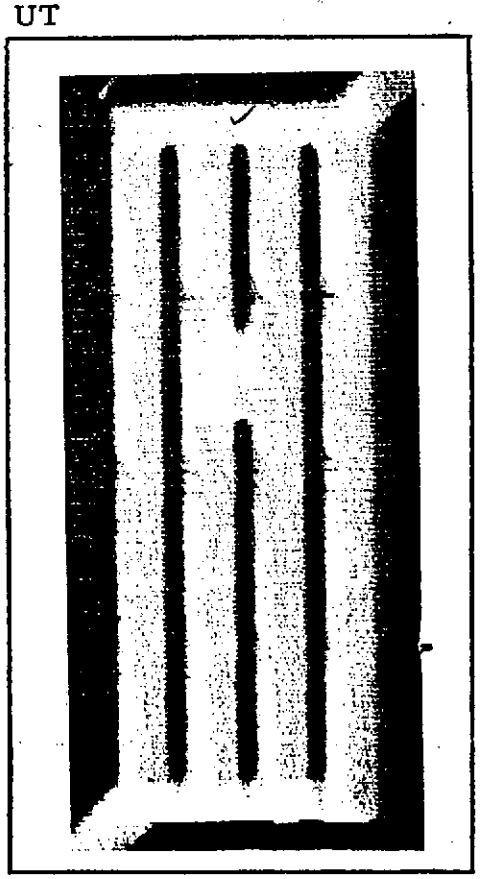


Press. 4.1 x 10^5 N/M^2
(60 PSI)

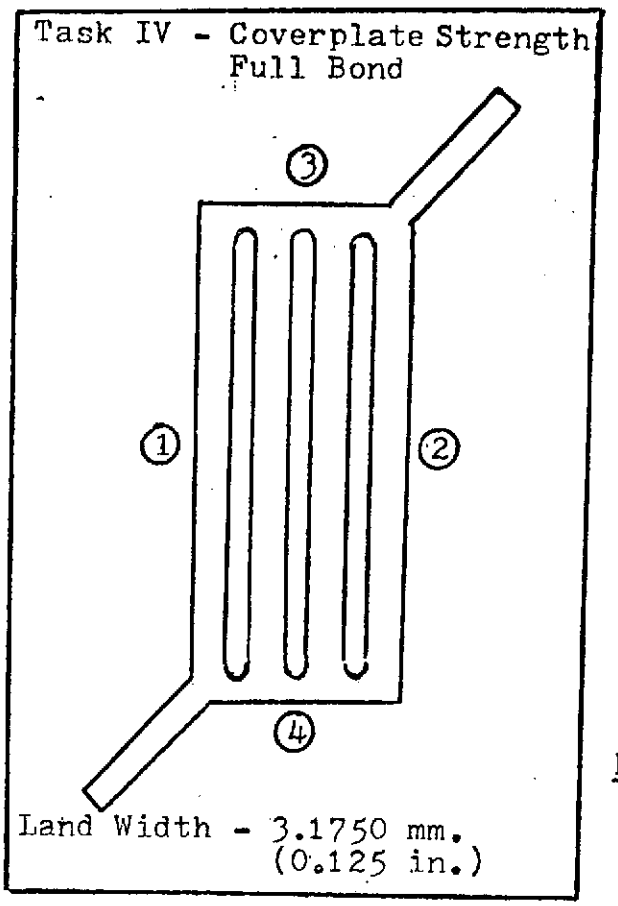
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-21



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.2499	0.2459
②	6.2078	0.2444
③	6.2205	0.2449
④	6.2001	0.2441

COVERPLATE

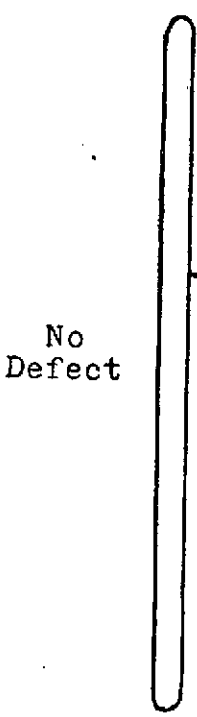
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9119	0.0359
②	0.9804	0.0386
③	0.9881	0.0389
④	1.0008	0.0394

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 5.52×10^7 N/m^2 (8,000 psi). Note that lower strength EF Nickel was used on this panel.

CENTER LAND DEFECT

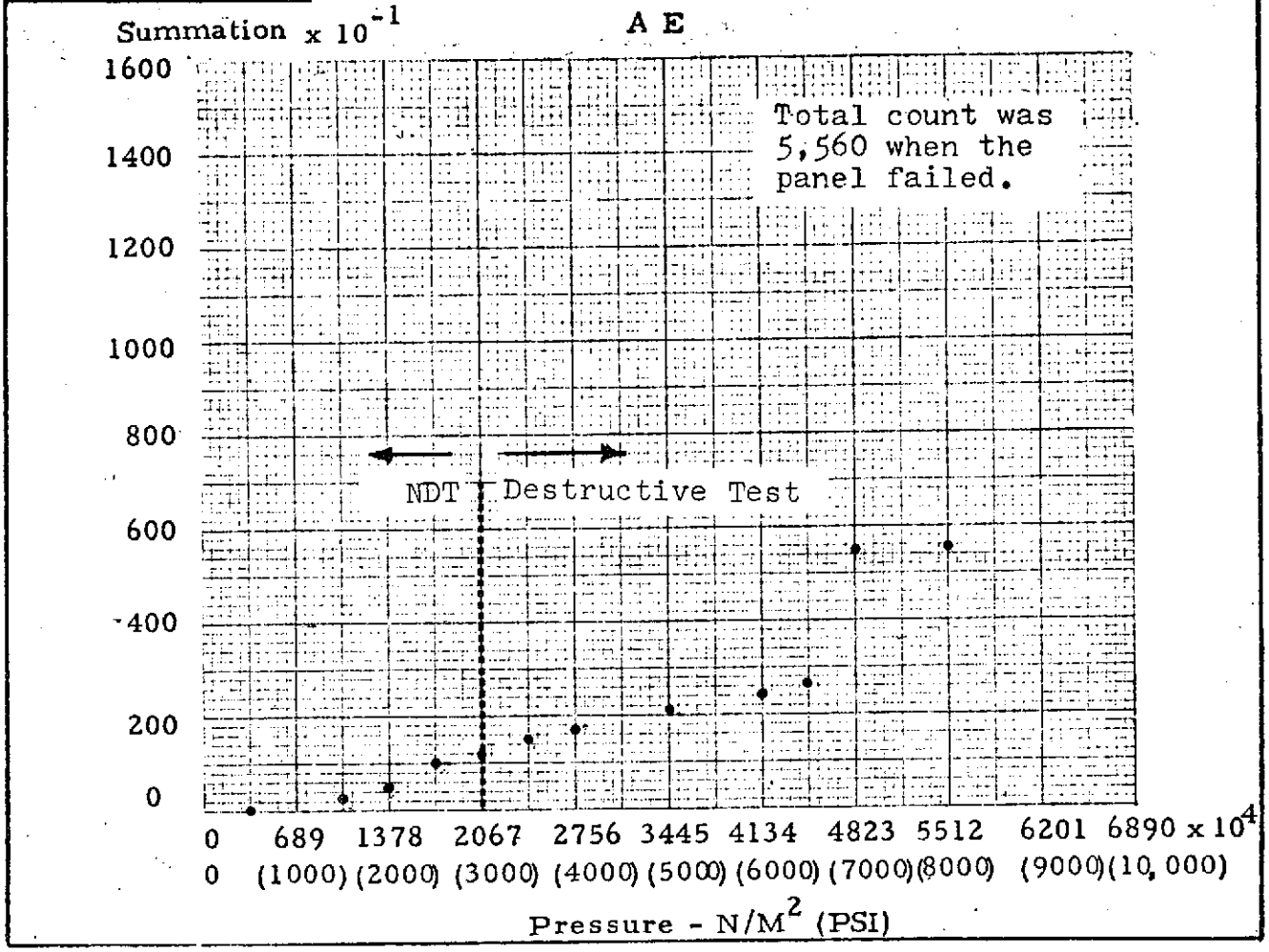


METALLOGRAPHIC ANALYSIS:

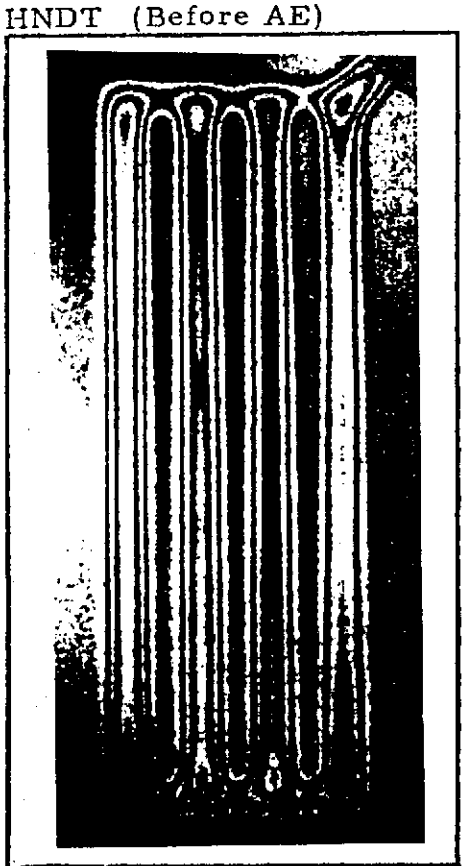
Section of full bond showing some failure occurring at the edge of the land. Magnification 50X.

FIGURE C-12

Panel No. N-21

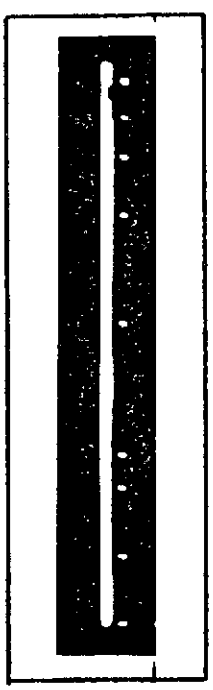


HNDT (Before AE)

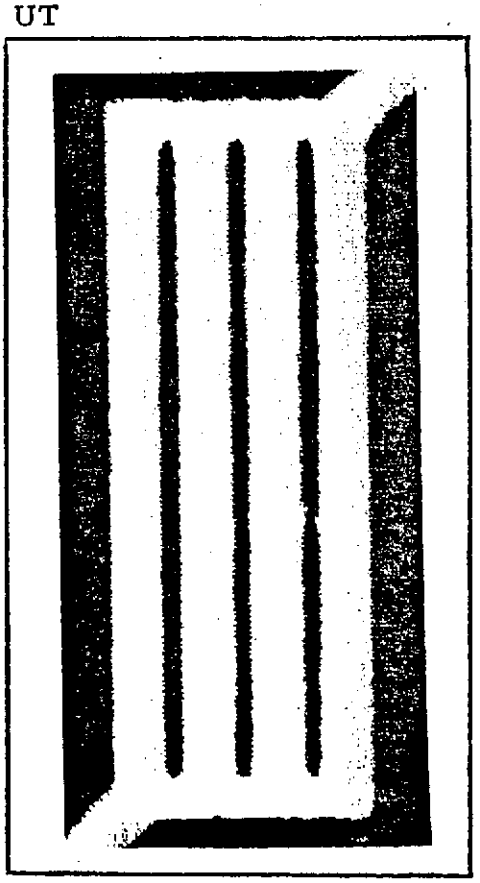


Press. - 13.8 x 10^5 N/M^2
(200 PSI)

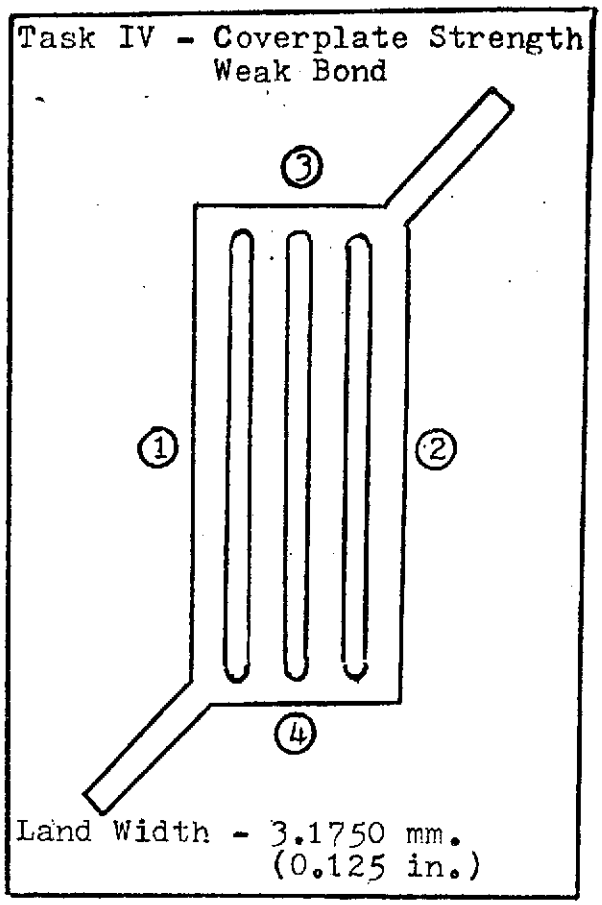
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-36



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.004 in. (0.1016 mm.)

THICKNESS:	MM.	INCHES
①	6.2052	0.2443
②	6.1951	0.2439
③	6.2332	0.2454
④	6.2001	0.2441

COVERPLATE

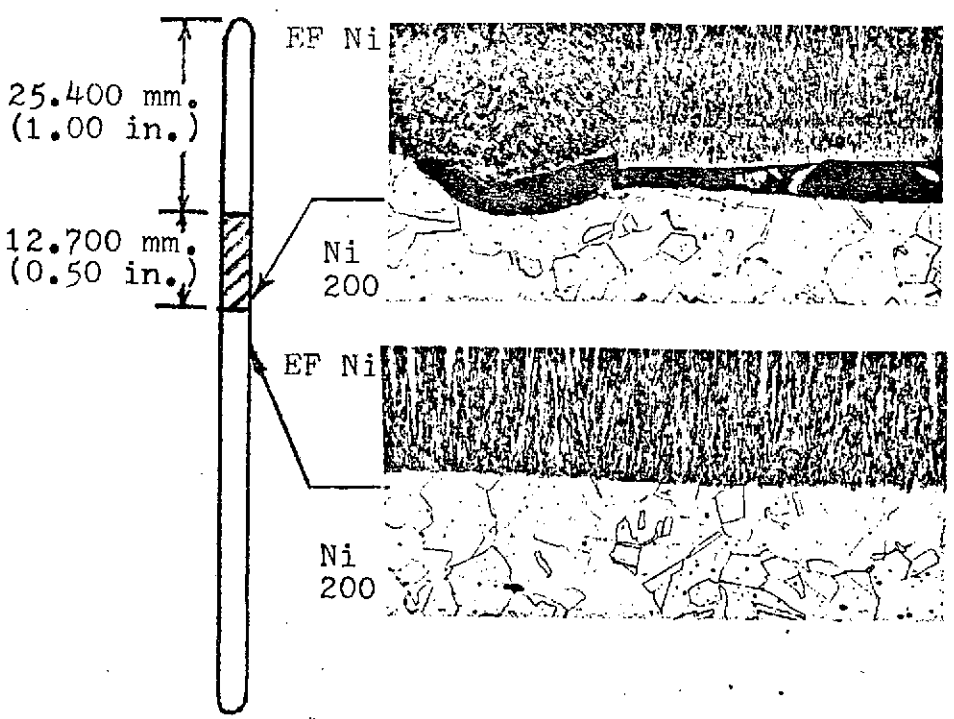
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9525	0.0375
②	0.9449	0.0372
③	0.9093	0.0358
④	0.9627	0.0379

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.76×10^7 N/m^2 (4,000 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

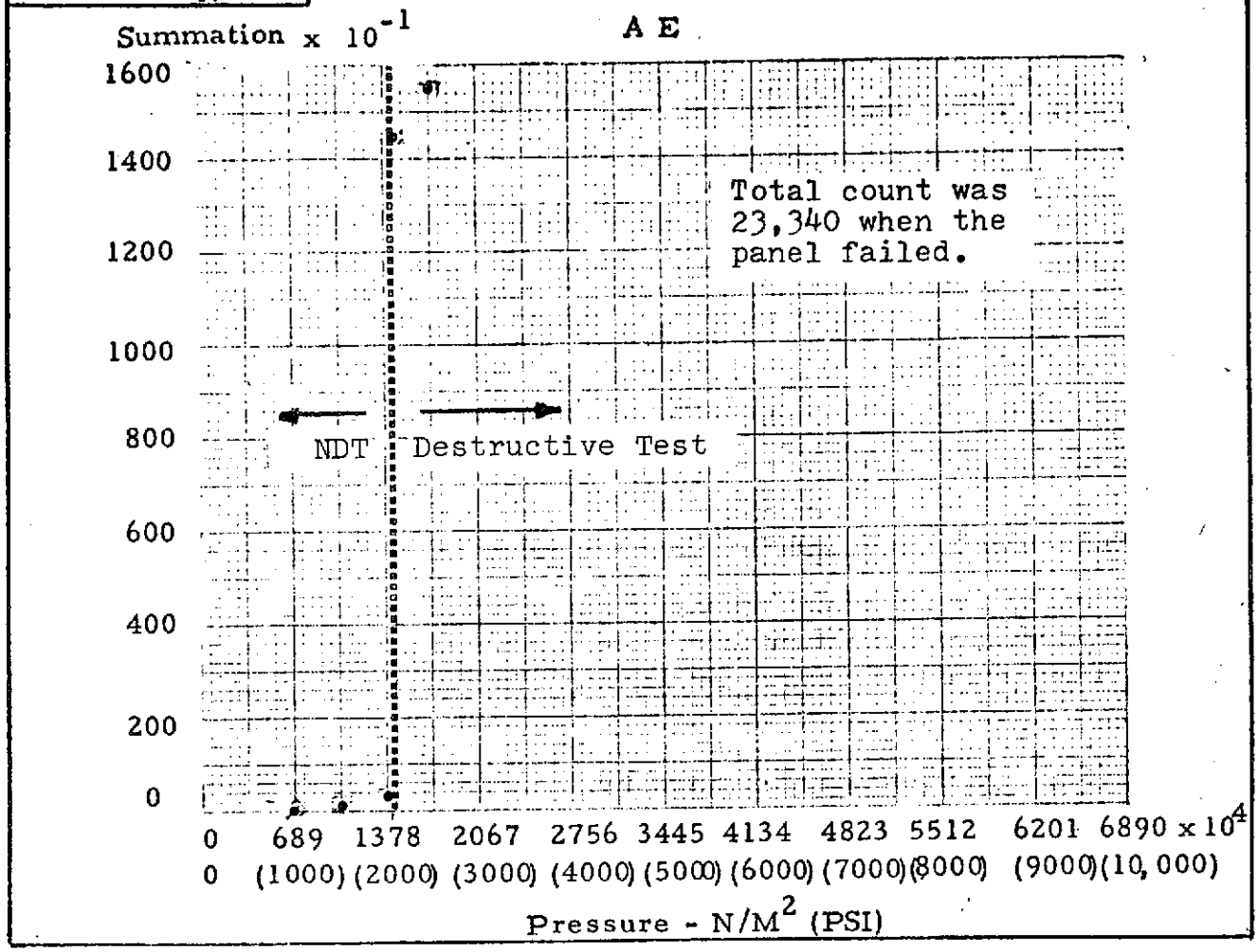
Weak bond section. Left edge of photo shows termination of weak bond. Magnification 50X.

Section showing full bond area next to planned weak bond. Magnification 50X.

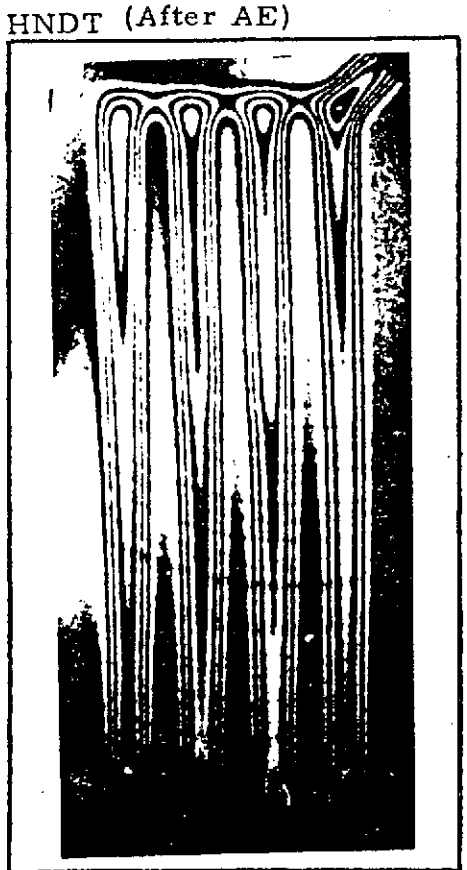
FIGURE C-13

C - 2

Panel No. N-36

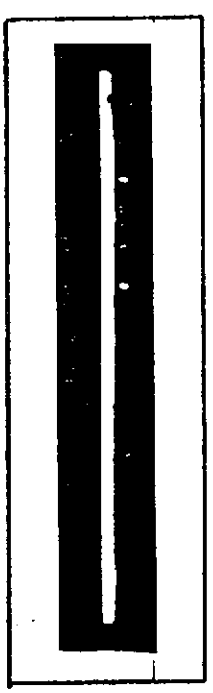


HNDT (After AE)

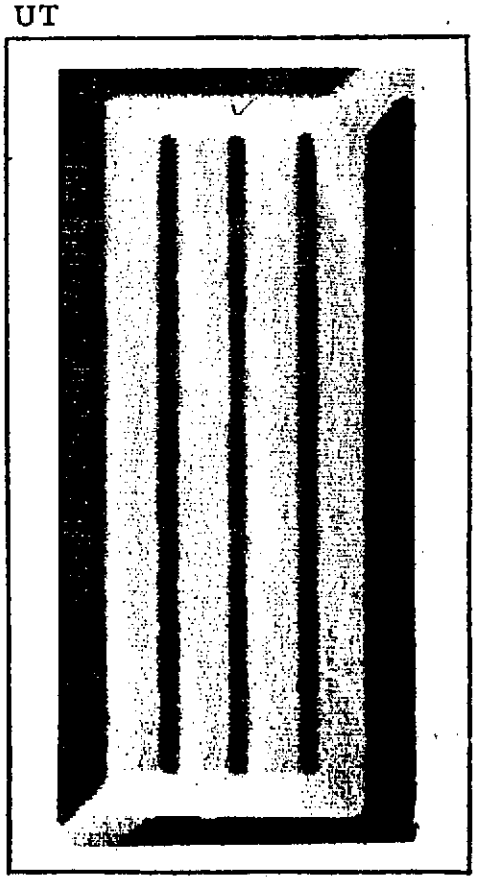


Press. 20.7 x 10^5 N/M^2
(300 PSI)

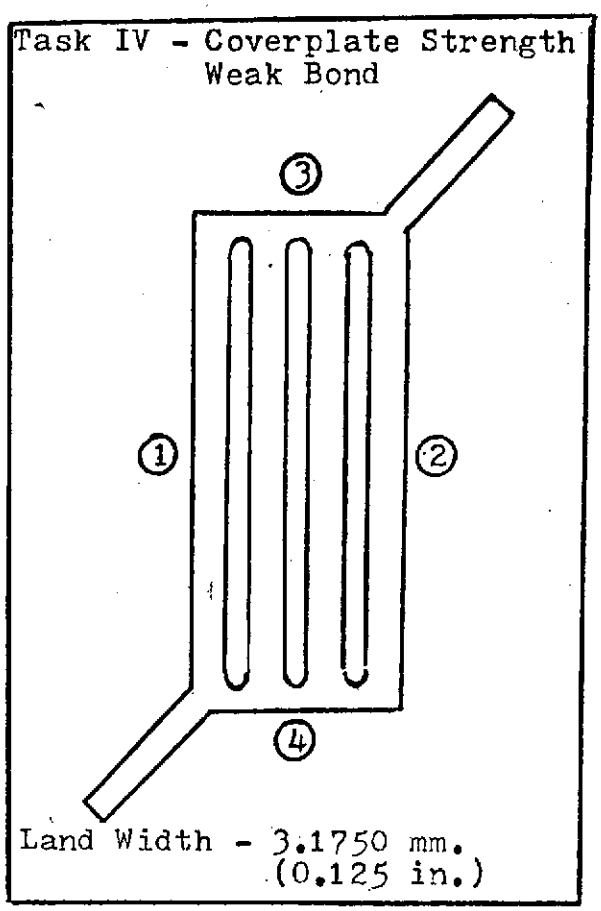
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-37



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.006 in. (0.1524 mm.)

THICKNESS:	MM.	INCHES
①	6.1798	0.2433
②	6.2052	0.2443
③	6.1925	0.2438
④	6.2027	0.2442

COVERPLATE

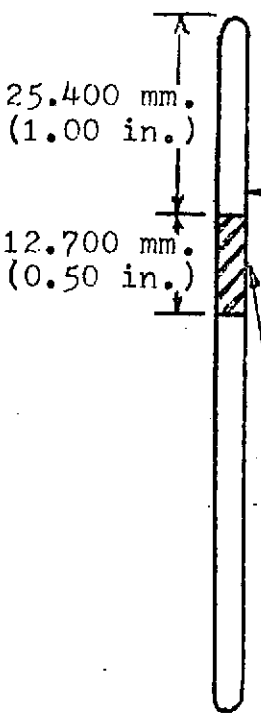
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9017	0.0355
②	0.9017	0.0355
③	1.0135	0.0399
④	0.9398	0.0370

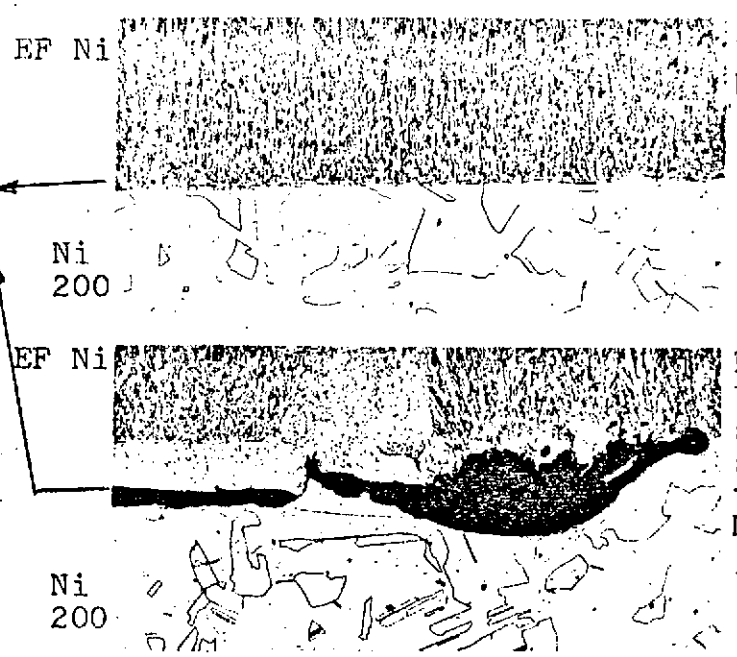
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.21×10^7 N/m^2 (3,200 psi)

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

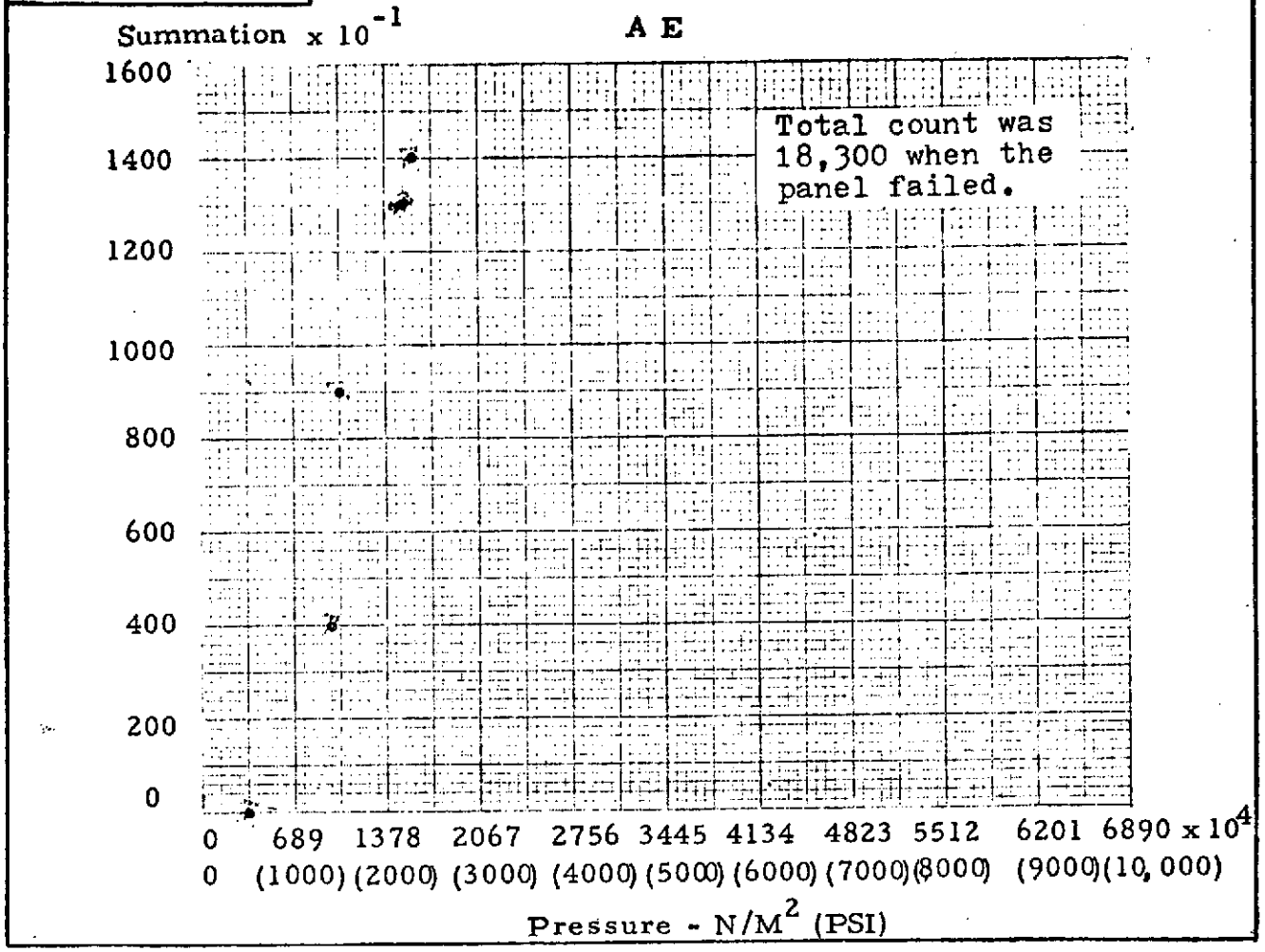


Full bond area. Magnification 50X.

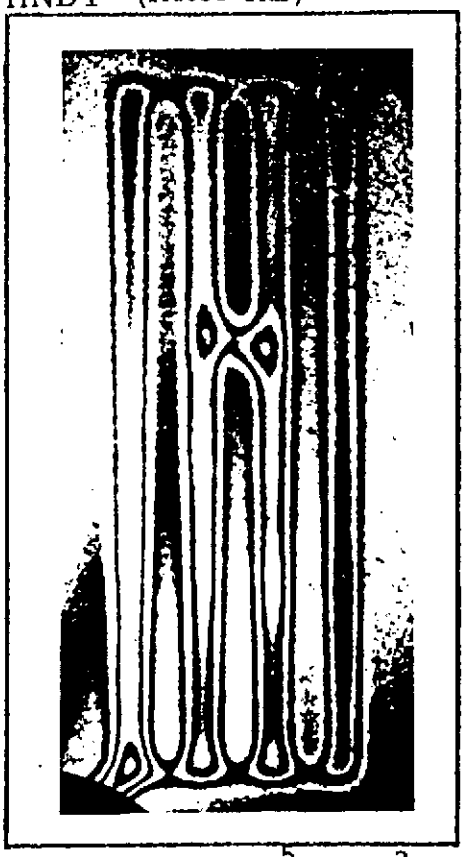
Planned weak bond. Right side of photo shows weak bond termination. Magnification 50X.

FIGURE C-14

Panel No. N-37

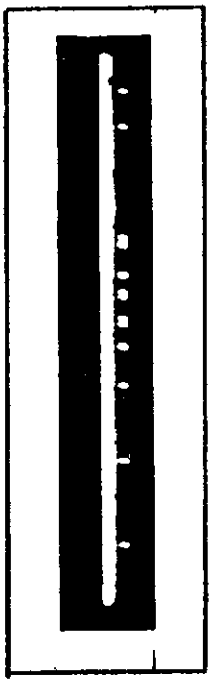


HNDT (After AE)

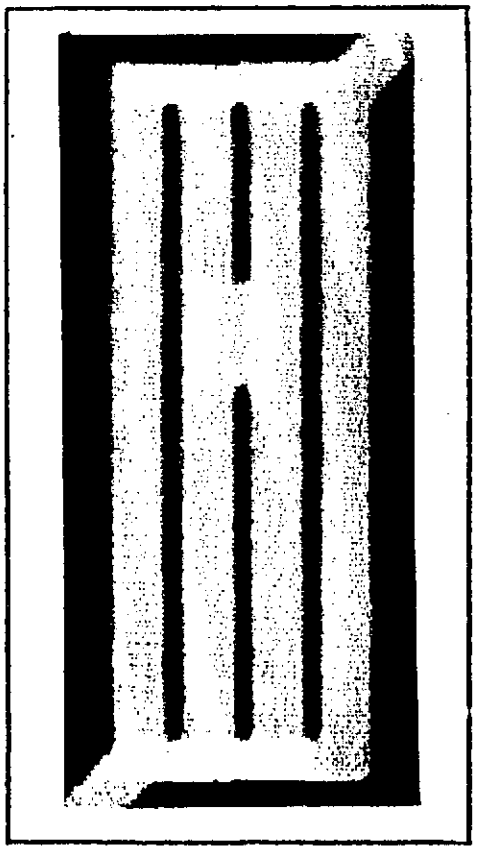


Press. 6.9 x 10^5 N/M^2
(100 PSI)

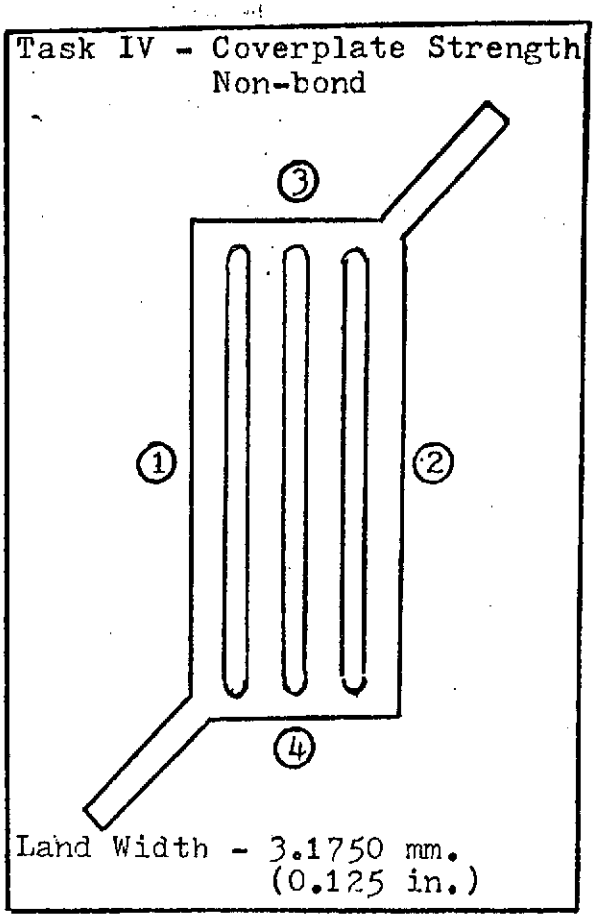
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-41 "A"



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.008 in. (0.2032 mm.)

THICKNESS:	MM.	INCHES
①	5.8217	0.2292
②	5.8801	0.2315
③	5.9639	0.2348
④	5.9436	0.2340

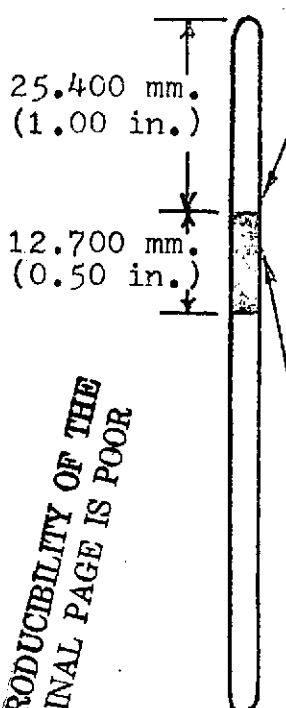
COVERPLATE

MATERIAL: Electroformed Nickel

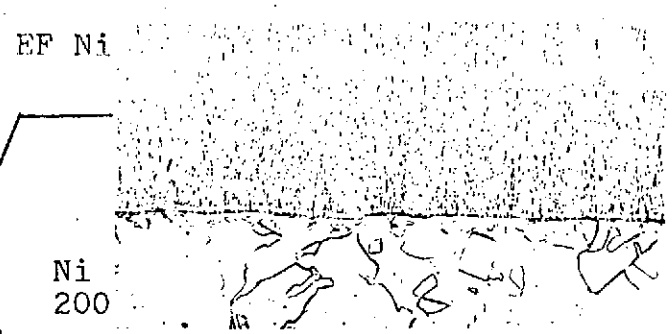
THICKNESS:	MM.	INCHES
①	0.9068	0.0357
②	0.8941	0.0352
③	0.8763	0.0345
④	0.8712	0.0343

PRESSURE REQUIRED TO FAIL BOND:
Panel failed at a pressure of
1.59×10^7 N/m^2 (2,300 psi).

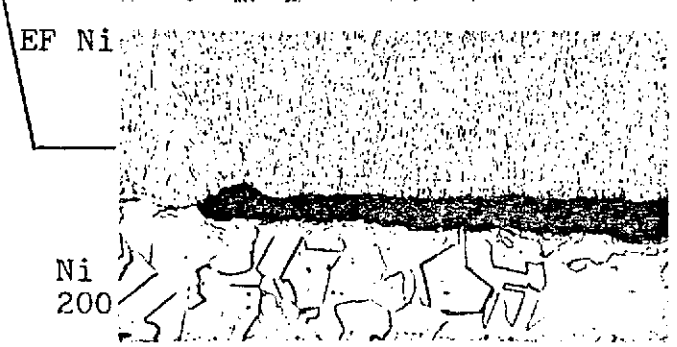
CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



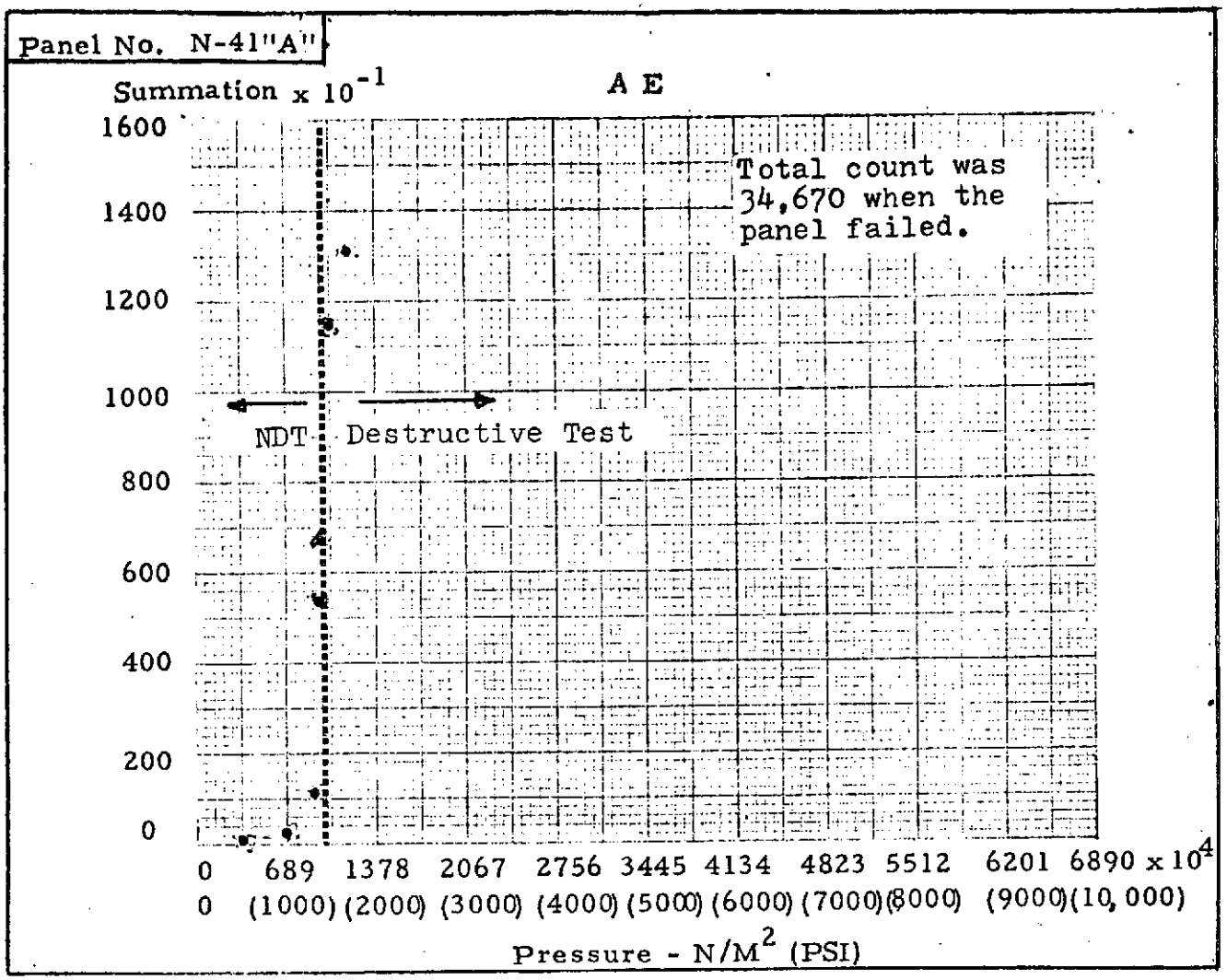
Full bond section next to the planned nonbond defect. Magnification 50X.



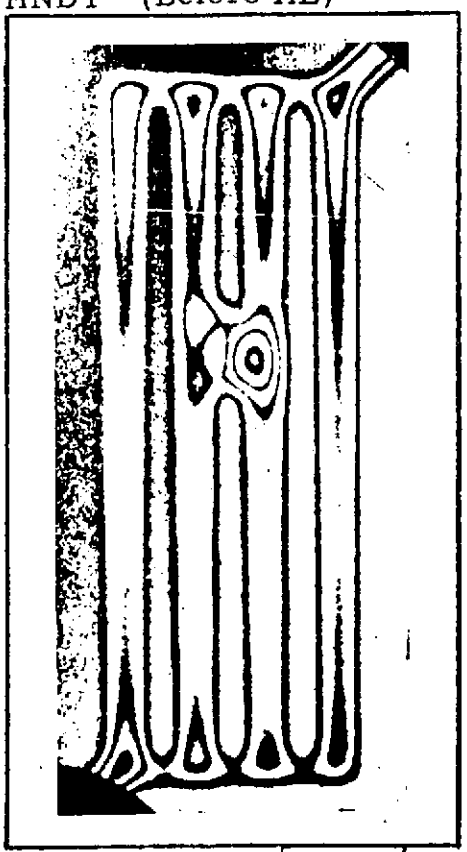
Section from the top end of the planned nonbond. Note failure separation. Magnification 50X.

FIGURE C-15

Panel No. N-41"A"

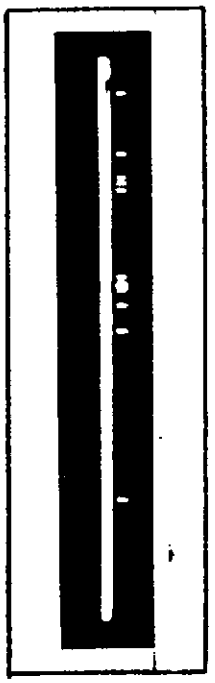


HNDT (Before AE)

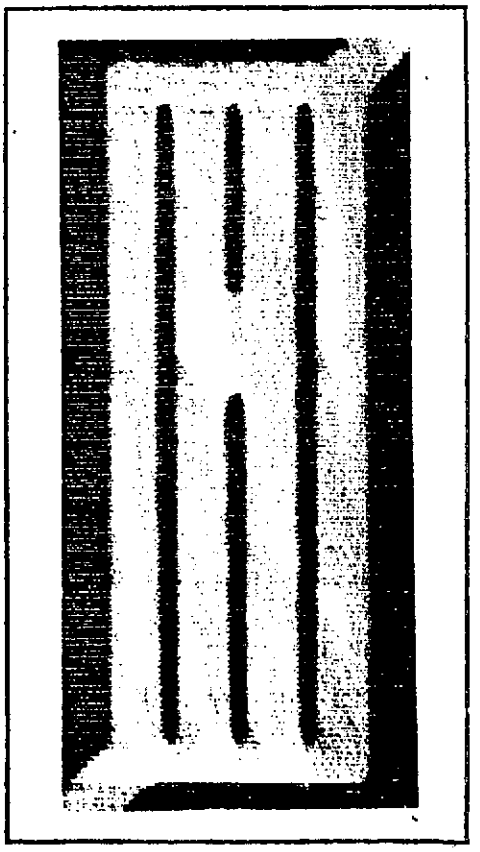


Press. 6.9 x 10^5 N/M^2
(100 PSI)

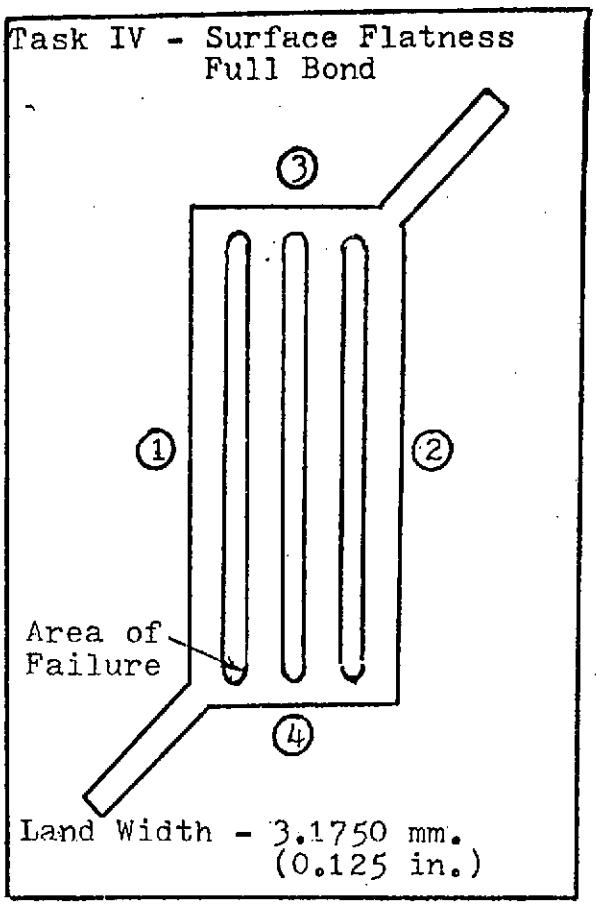
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-13



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.006 in. (0.1524 mm.)

THICKNESS:	MM.	INCHES
①	6.2230	0.2450
②	6.2306	0.2453
③	6.2586	0.2464
④	6.2763	0.2471

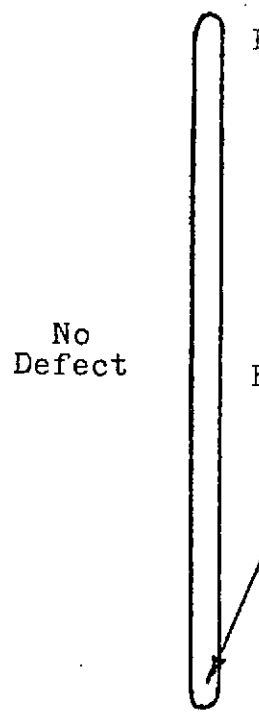
COVERPLATE

MATERIAL: Electroformed Nickel

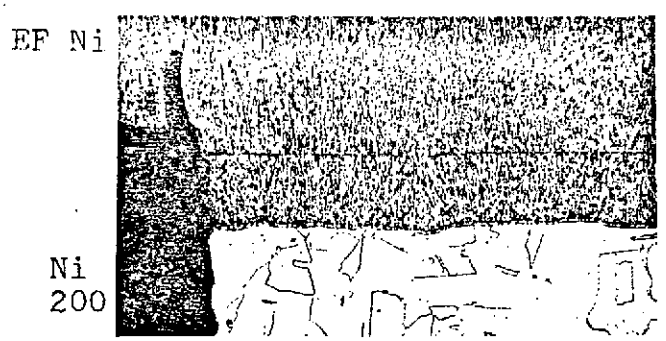
THICKNESS:	MM.	INCHES
①	0.7874	0.0310
②	0.7442	0.0293
③	0.9017	0.0355
④	0.6325	0.0249

PRESSURE REQUIRED TO FAIL BOND:
Panel failed at a pressure of 5.11×10^7 N/m^2 (7,400 psi).

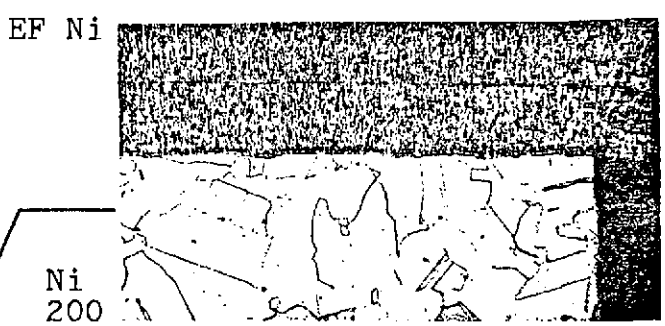
CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



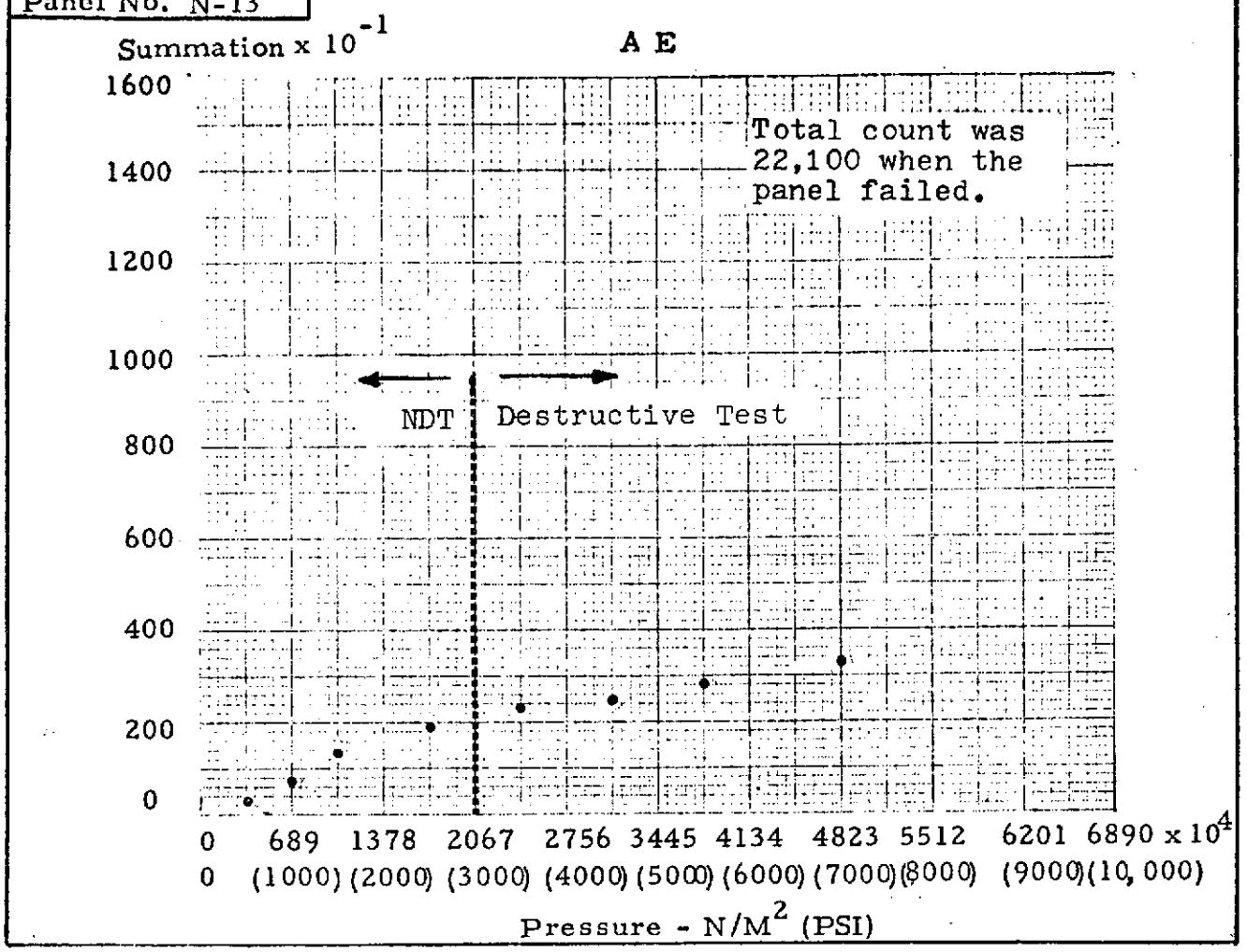
Failure occurred at bottom ends of lands. Section shows failure as initiated through EF Nickel over the channel near Land 1. Magnification 50X.



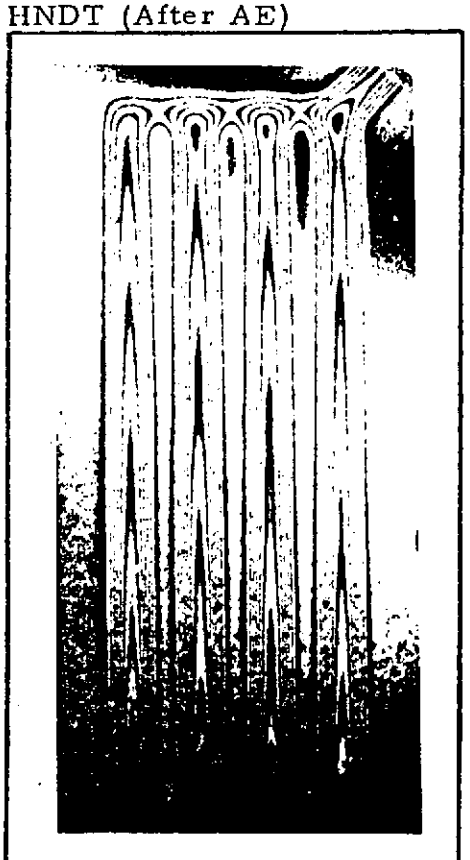
Section of full bond at bottom end of Land 2. No failure detected. Magnification 50X.

FIGURE C-16

Panel No. N-13

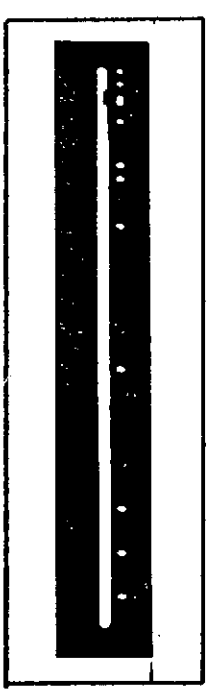


HNDT (After AE)

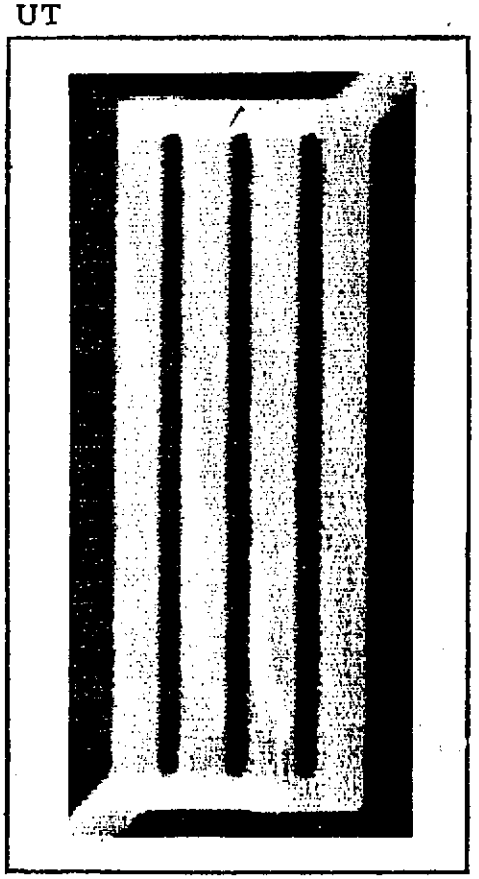


Press. - 20.7 x 10^5 N/M^2
(300 PSI)

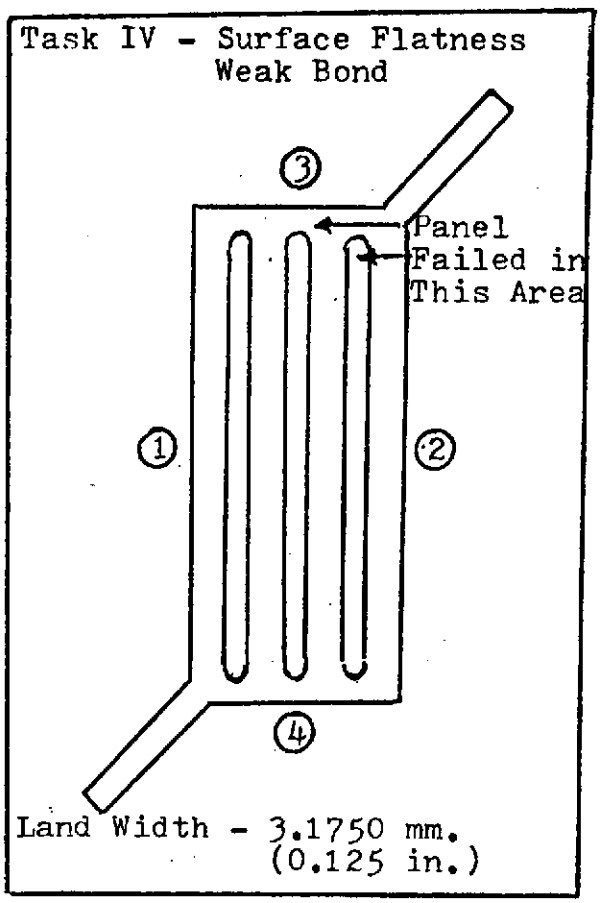
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-46



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION:
0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.2636	0.2466
②	6.2382	0.2456
③	6.2814	0.2473
④	6.2103	0.2445

COVERPLATE

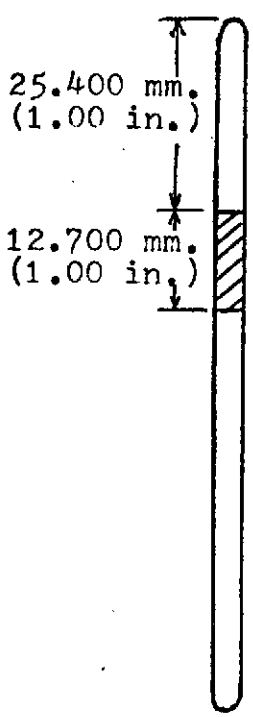
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.8941	0.0352
②	0.9042	0.0356
③	0.7391	0.0291
④	1.0389	0.0409

PRESSURE REQUIRED TO FAIL BOND:

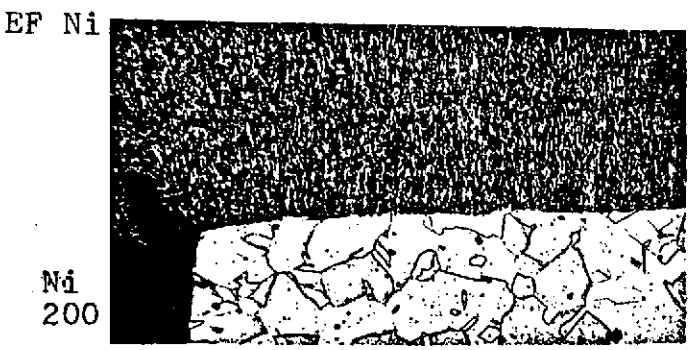
Panel failed at a pressure of 5.87×10^7 N/m^2 (8,500 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

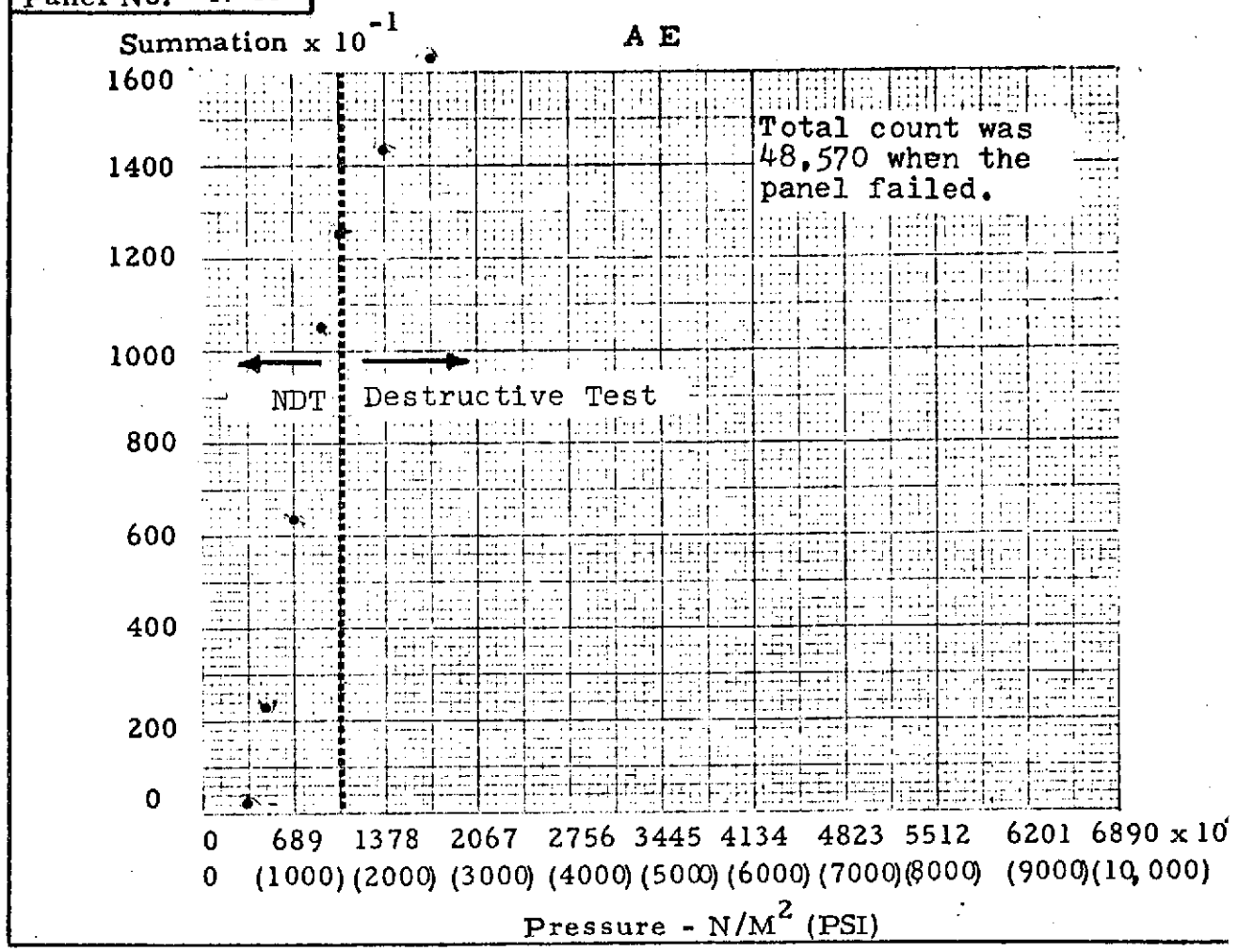
Section from the planned weak bond showing progress of failure. Magnification 50X.



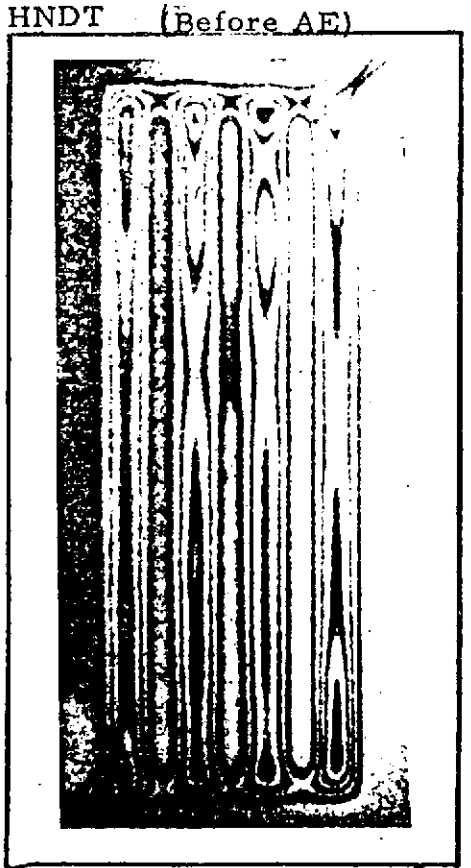
Section of the full bond from Land 3 illustrating no bond failure, but some tearing of the thin coverplate is evident. Magnification 50X.

FIGURE C-17

Panel No. N-46

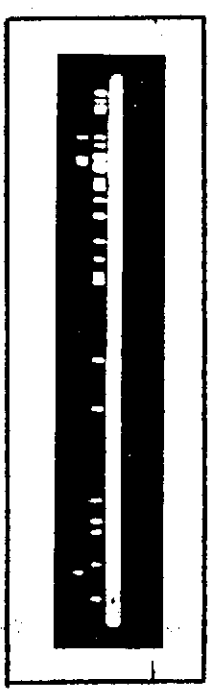


HNDT (Before AE)

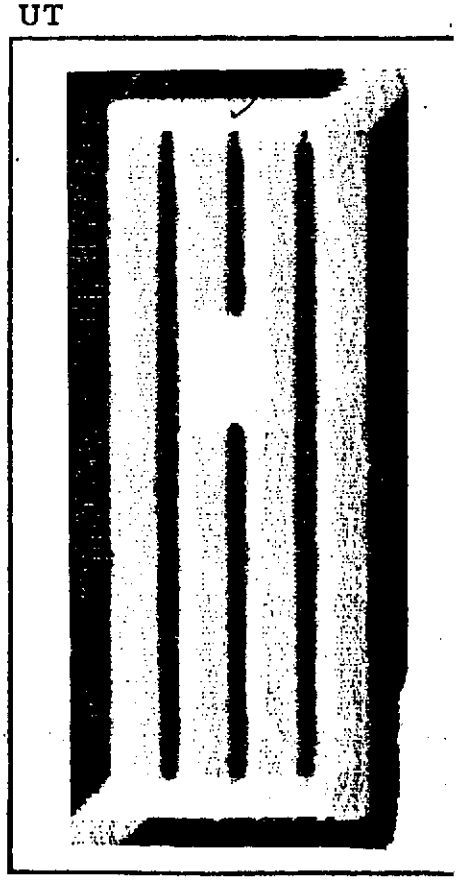


Press. 13.8 x 10^5 N/M^2 (200 PSI)

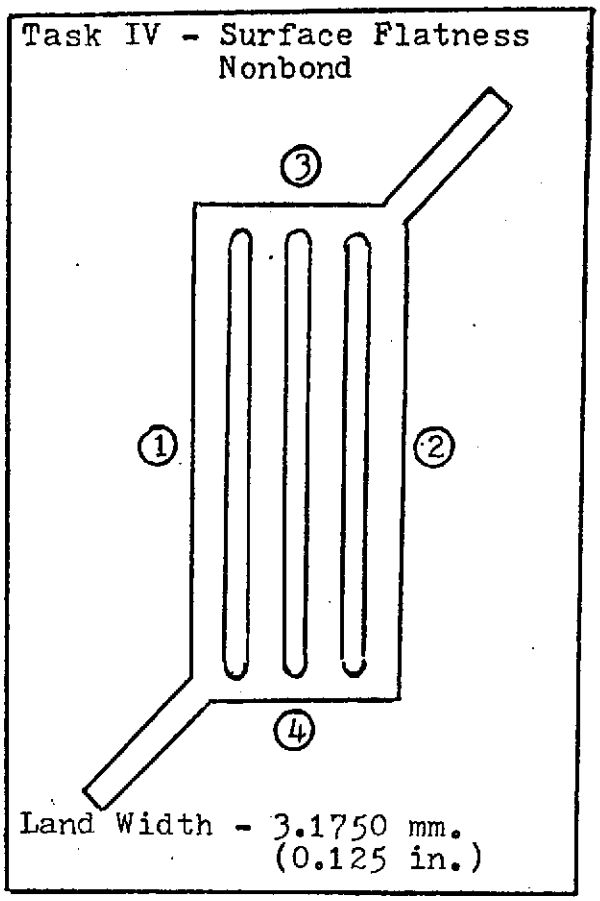
AE FLAW LOCATOR CENTER LAND



UT



ELECTROFORMED PANEL NO. N-42



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.005 in. (0.1270 mm.)

THICKNESS:	MM.	INCHES
①	6.2662	0.2467
②	6.2535	0.2462
③	6.2687	0.2468
④	6.2509	0.2461

COVERPLATE

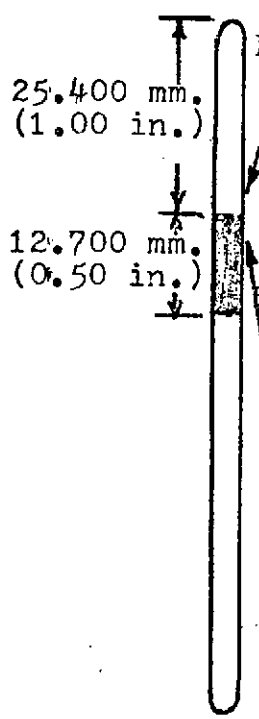
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.8153	0.0321
②	0.8306	0.0327
③	0.7874	0.0310
④	0.9830	0.0387

PRESSURE REQUIRED TO FAIL BOND:

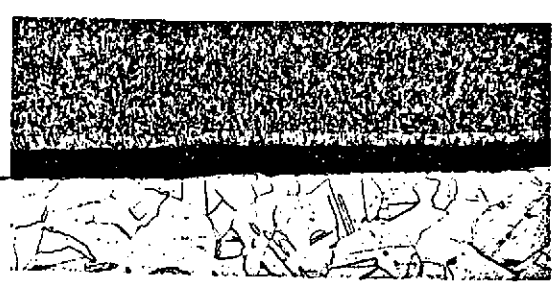
Panel failed at a pressure of 2.42×10^7 N/m^2 (3,500 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

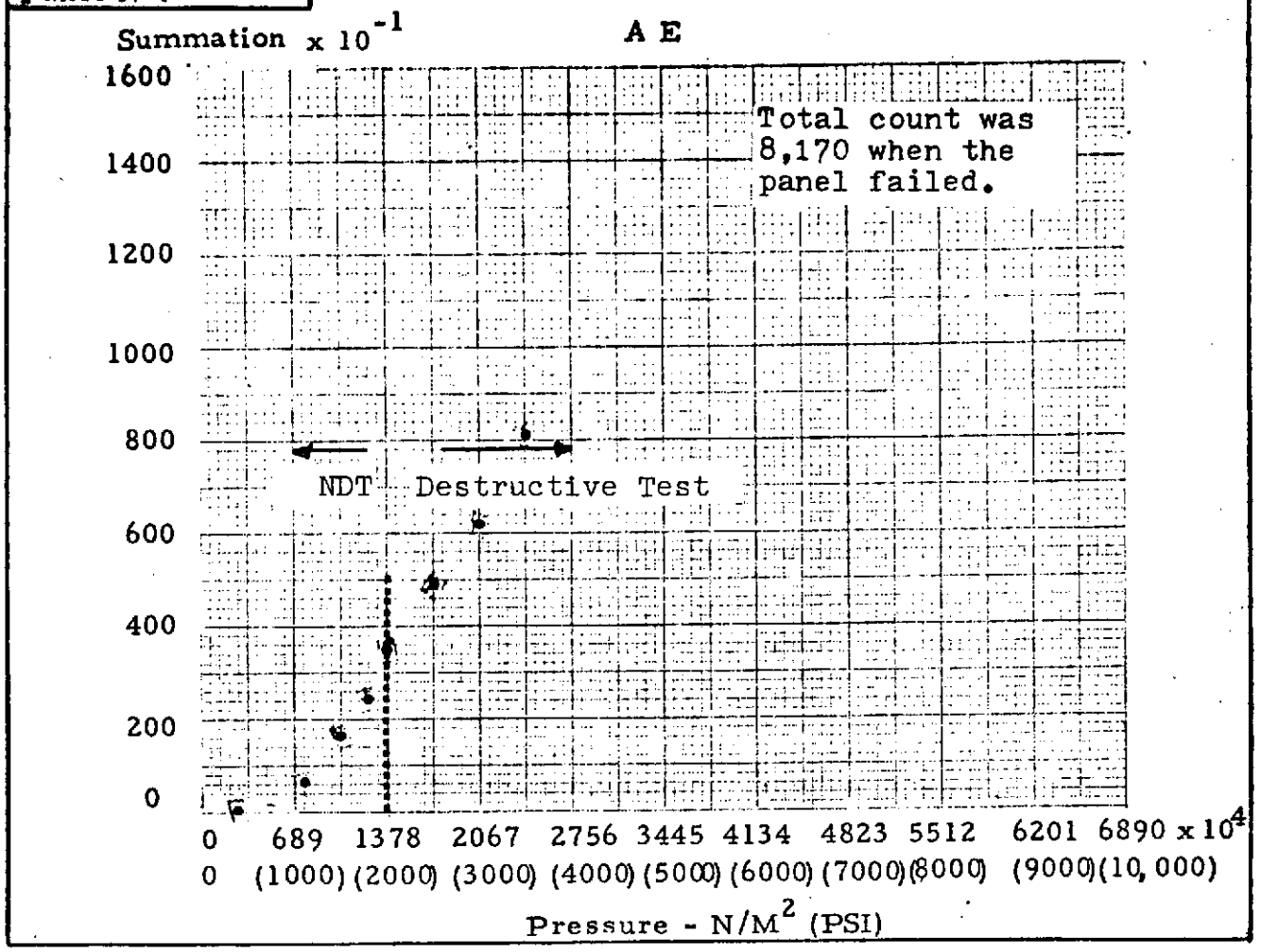
Full bond area next to planned nonbond. No bond failure is evident. Magnification 50X.



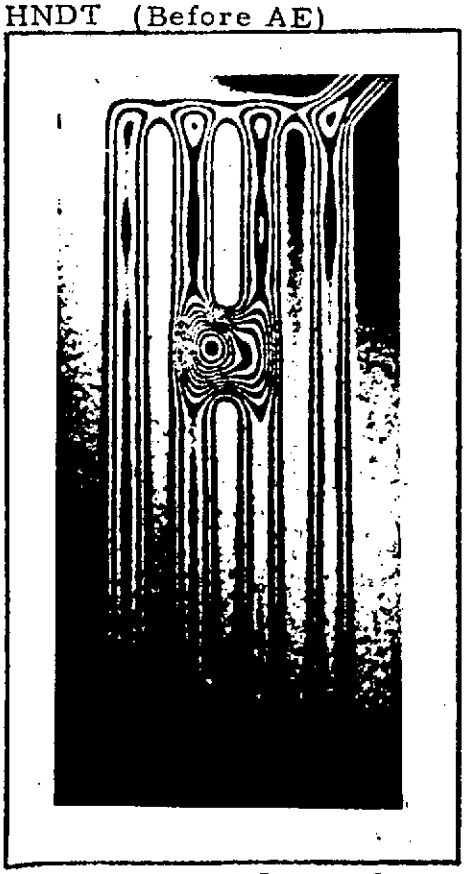
Planned nonbond section showing the bondline separation with lack of metal disturbance. Magnification 50X.

FIGURE C-18

Panel No. N-42

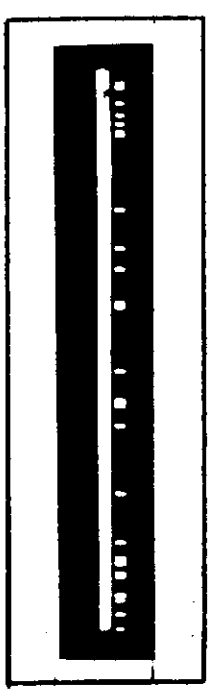


HNDT (Before AE)

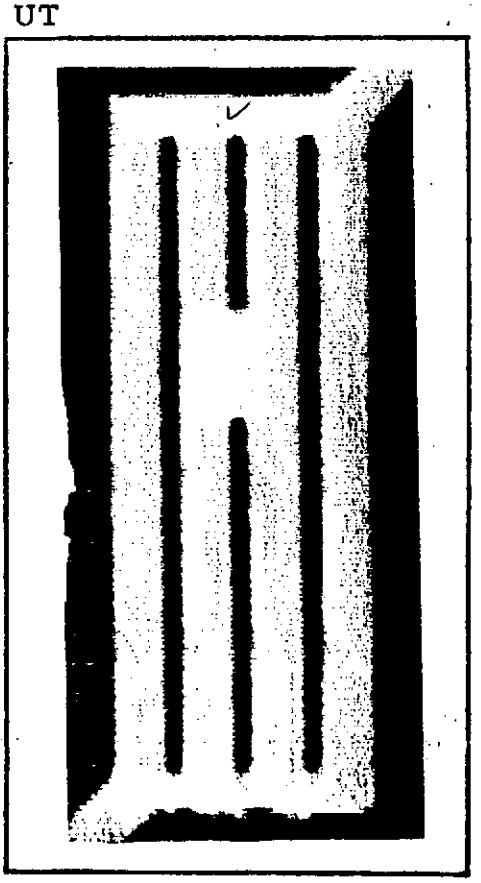


Press. 6.9×10^5 N/M^2
(100 PSI)

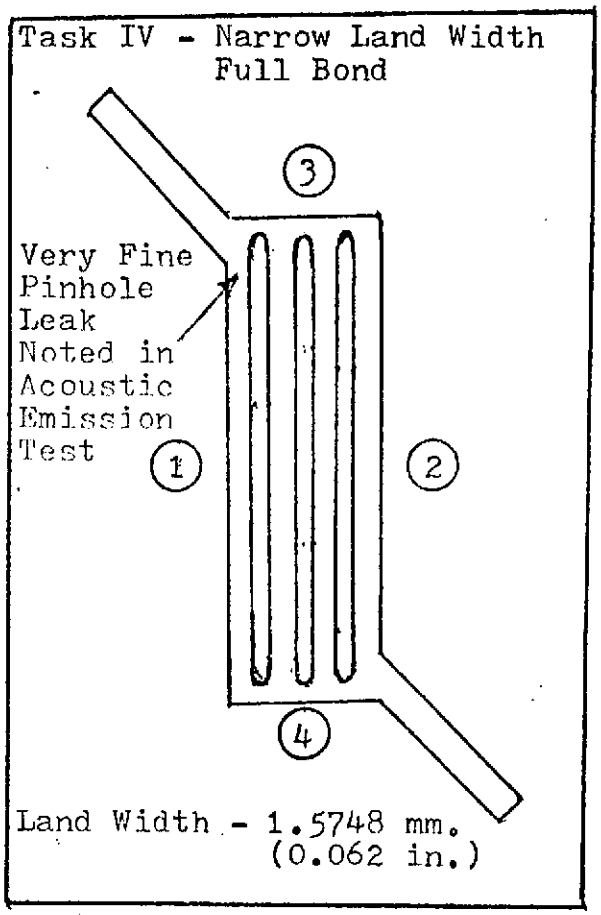
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-56



BASEPLATE

MATERIAL: Nickel 200

CENTER LAND FLATNESS VARIATION: 0.0025 in. (0.0635 mm.)

THICKNESS:	MM.	INCHES
①	6.2128	0.2446
②	6.2814	0.2473
③	6.2738	0.2470
④	6.2154	0.2447

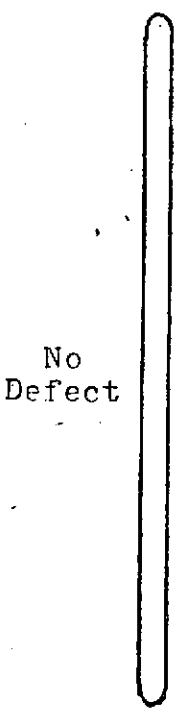
COVERPLATE

MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.0033	0.0395
②	0.9449	0.0372
③	0.9627	0.0379
④	1.0312	0.0406

PRESSURE REQUIRED TO FAIL BOND: Not destructively tested. Panel was fabricated to demonstrate NDE response on narrower lands only.

CENTER LAND DEFECT

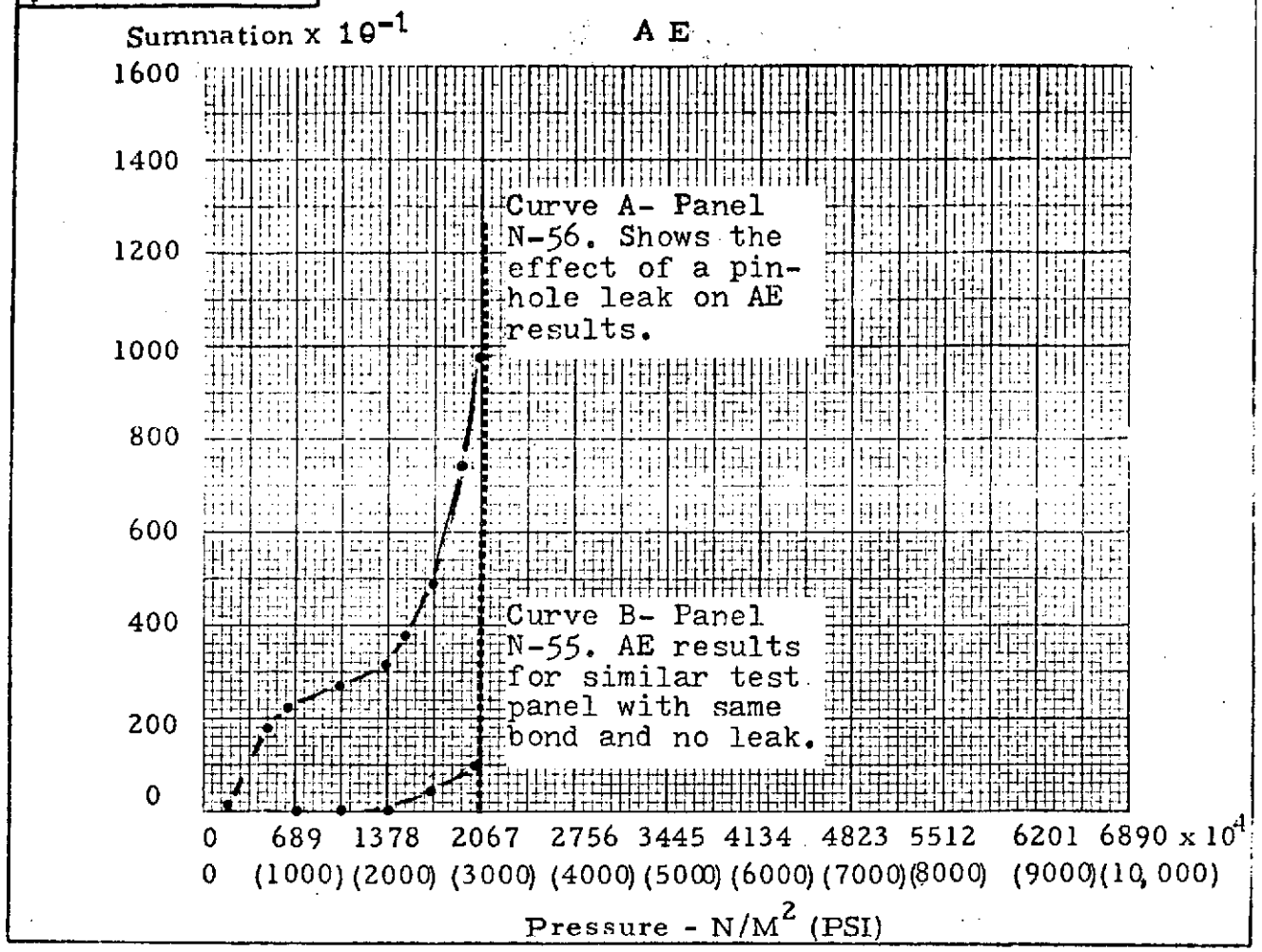


METALLURGICAL ANALYSIS: Not Required.

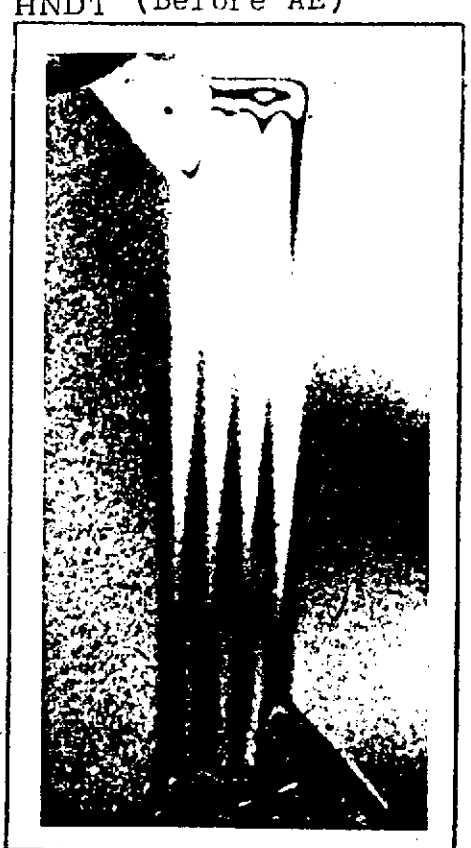
A low pressure pinhole type leak was noted in Panel N-56 during acoustic emission test. Although this condition can be effectively repaired, the results were shown as experienced for informational purposes. Panel N-55, an identical panel except for slightly thicker coverplate, was similarly tested by acoustic emission and the results plotted for the comparison shown on Page 107. Panel N-55 exhibited no leaks. Note the flaw locator response to the leak detected on Panel N-56.

FIGURE C-19

Panel No. N-56

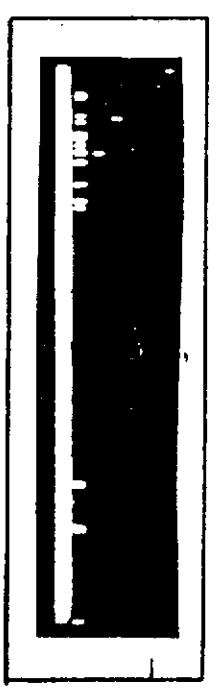


HNDT (Before AE)

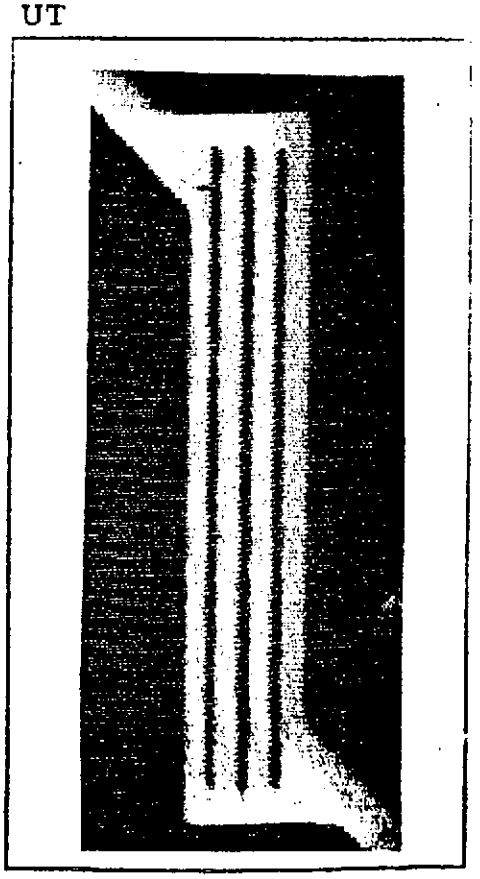


Press. 20.7 x 10^5 N/M^2 (300 PSI)

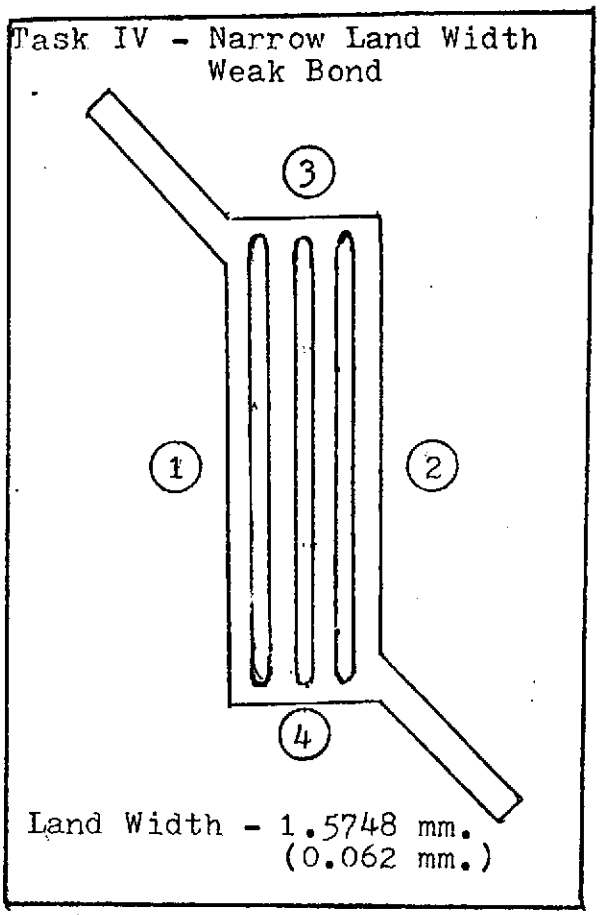
AE FLAW LOCATOR CENTER LAND



UT



ELECTROFORMED PANEL NO. N-57



BASEPLATE

MATERIAL: Nickel 200
CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.).

THICKNESS:	MM.	INCHES
①	6.2433	0.2458
②	6.2408	0.2457
③	6.2484	0.2460
④	6.2357	0.2455

COVERPLATE

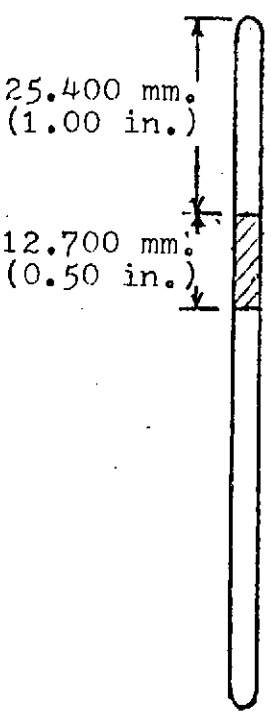
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.0262	0.0404
②	1.0389	0.0409
③	1.0312	0.0406
④	1.0135	0.0399

PRESSURE REQUIRED TO FAIL BOND:

Not destructively tested. Panel was fabricated to demonstrate NDE response on narrower lands only.

CENTER LAND DEFECT

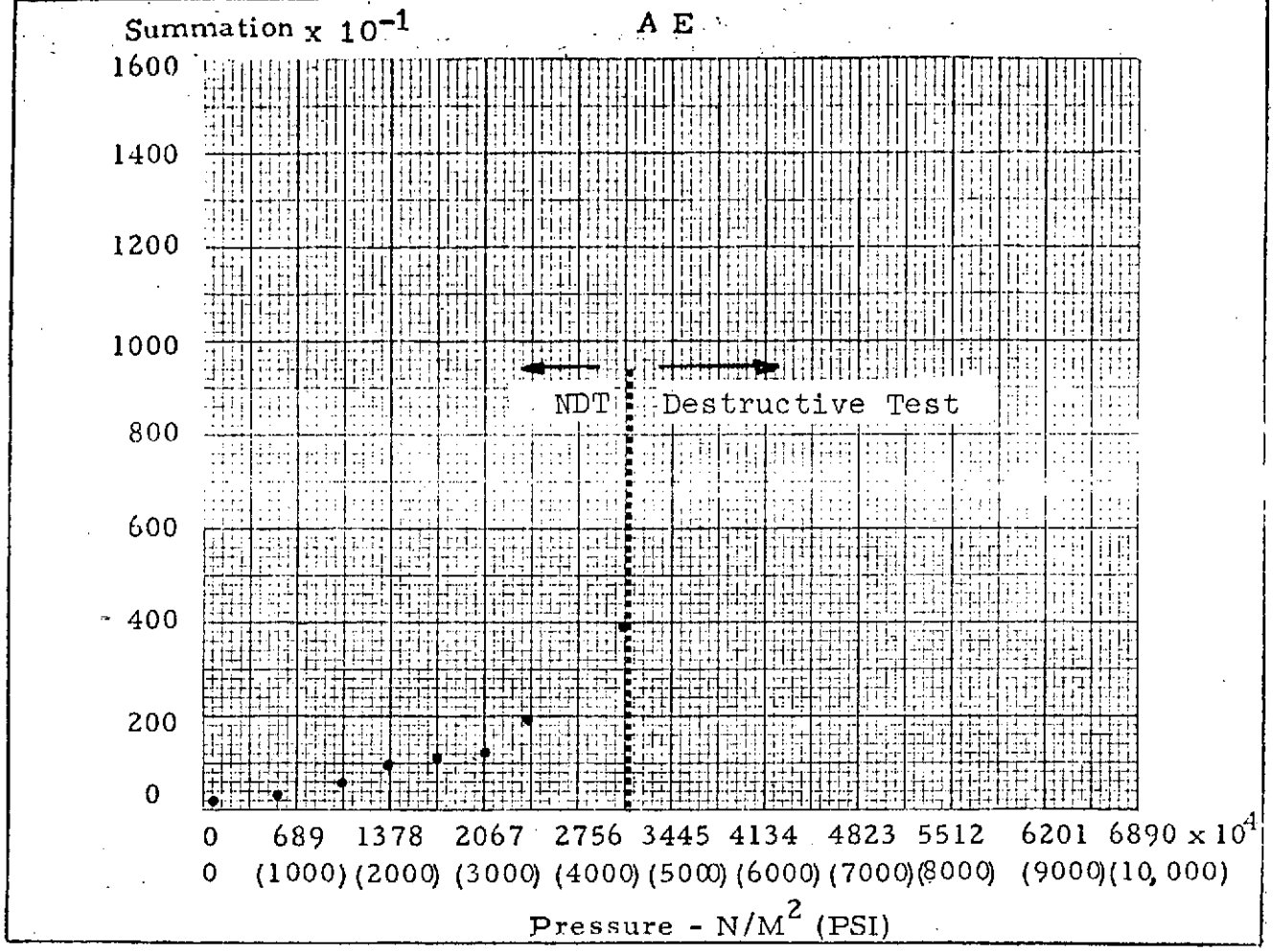


METALLURGICAL ANALYSIS: Not Required.

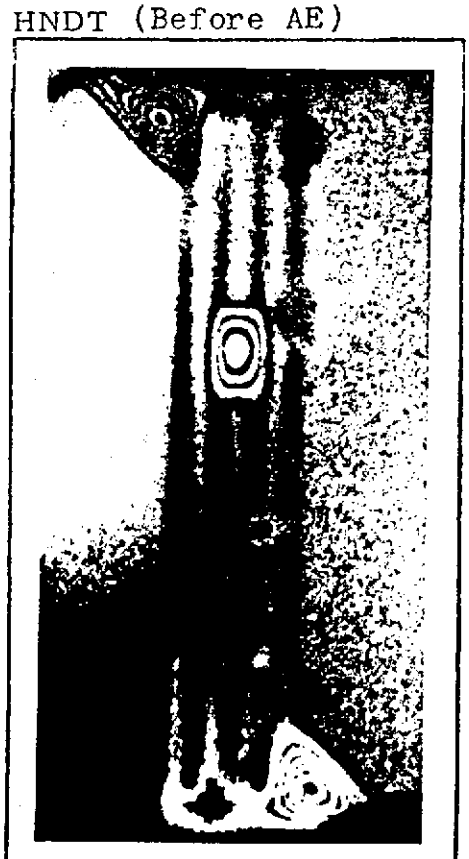
Planned weak bond was actually a nonbond as disclosed by ultrasonic "C" scan and holography. The low pressure acoustic response did not show the high count normal for weak bonds.

FIGURE C-20

Panel No. N-57

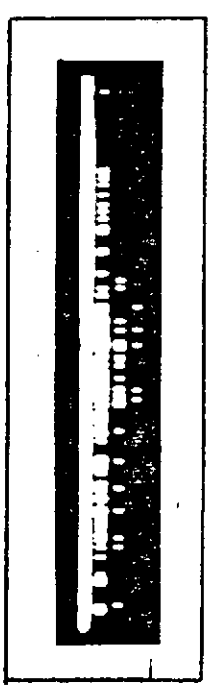


HNDT (Before AE)

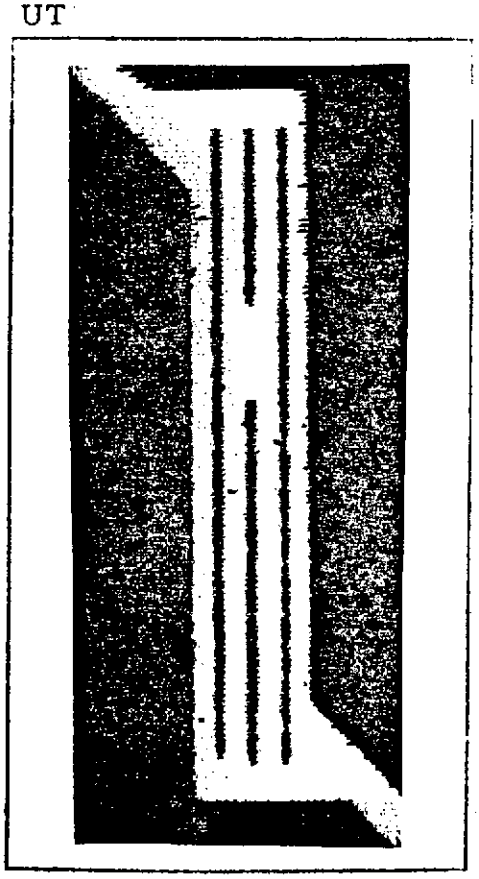


Press. 3.45 x 10^5 N/M^2
(50 PSI)

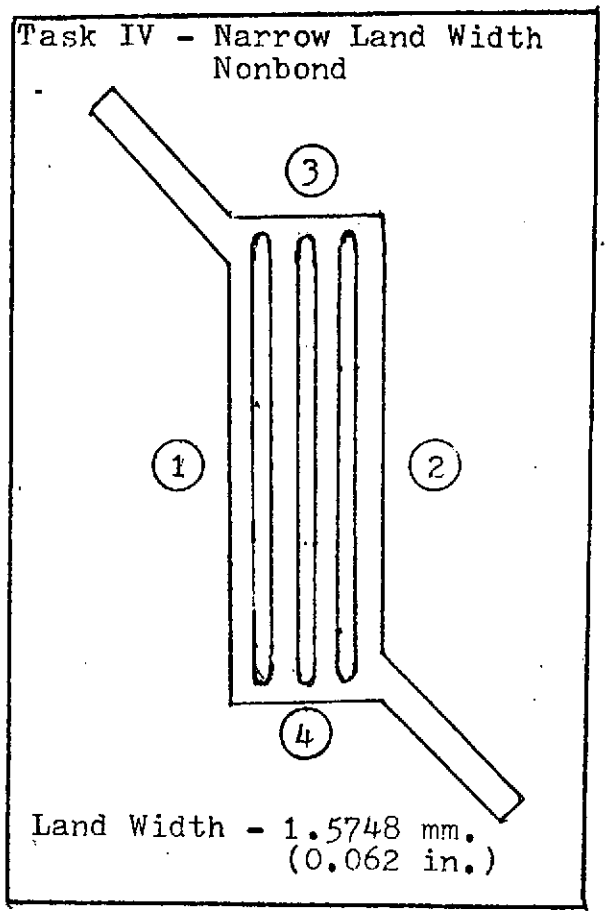
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. N-58



BASEPLATE

MATERIAL: Nickel 200
CENTER LAND FLATNESS VARIATION:
0.0065 in. (0.1651 mm.)

THICKNESS:	MM.	INCHES
①	6.2128	0.2446
②	6.2027	0.2442
③	6.1951	0.2439
④	6.2053	0.2443

COVERPLATE

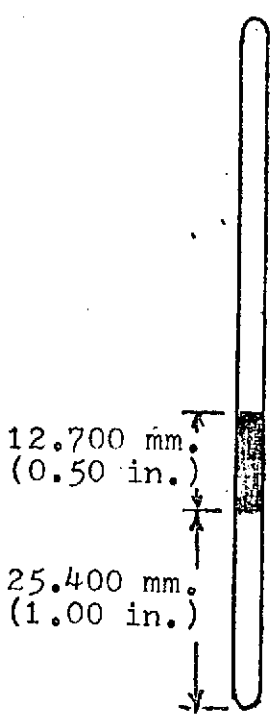
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	1.0328	0.0407
②	1.0389	0.0409
③	0.8966	0.0353
④	0.9398	0.0370

PRESSURE REQUIRED TO FAIL BOND:

Not destructively tested. Panel was fabricated to demonstrate NDE response on narrower lands only.

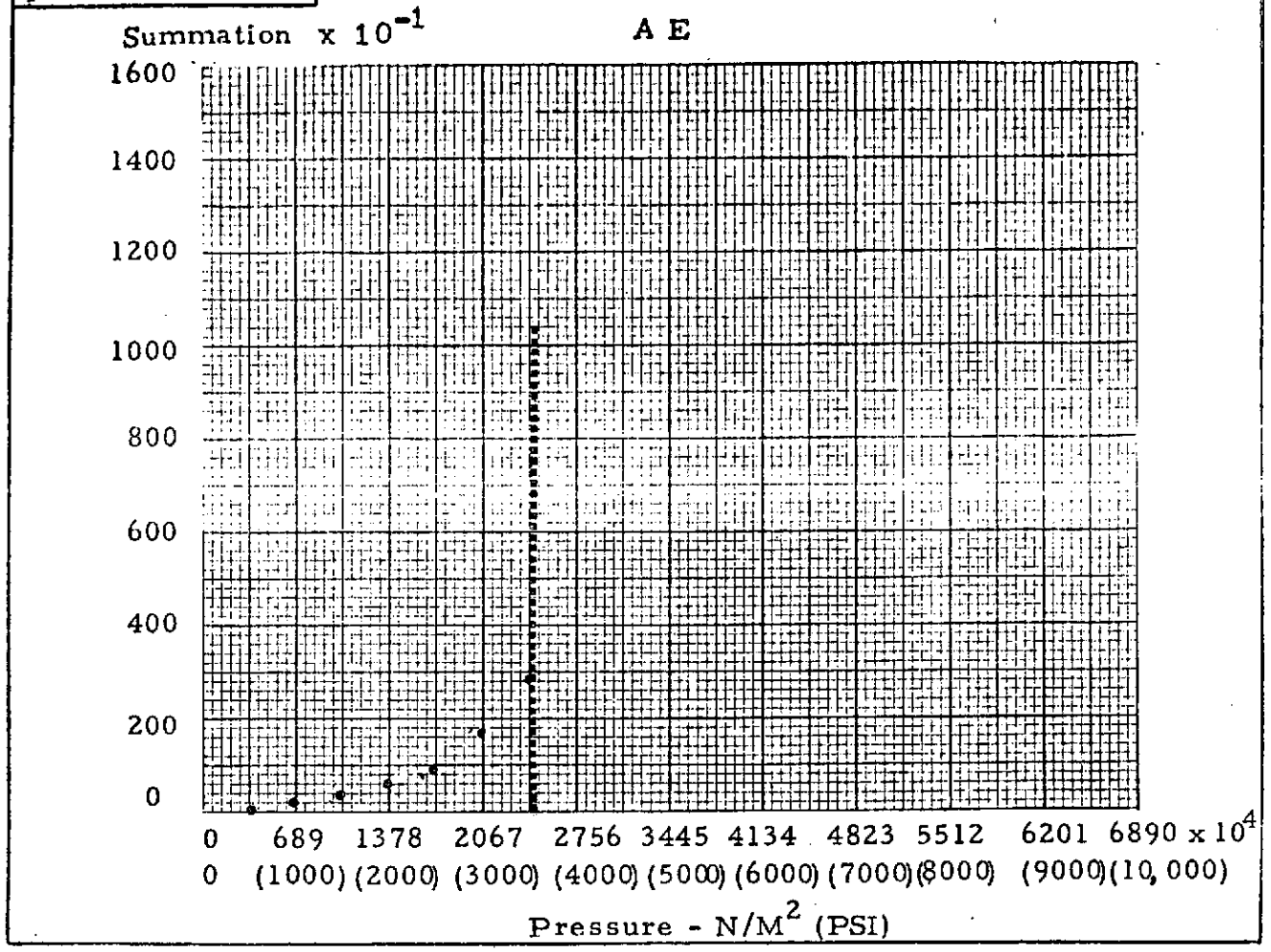
CENTER LAND DEFECT



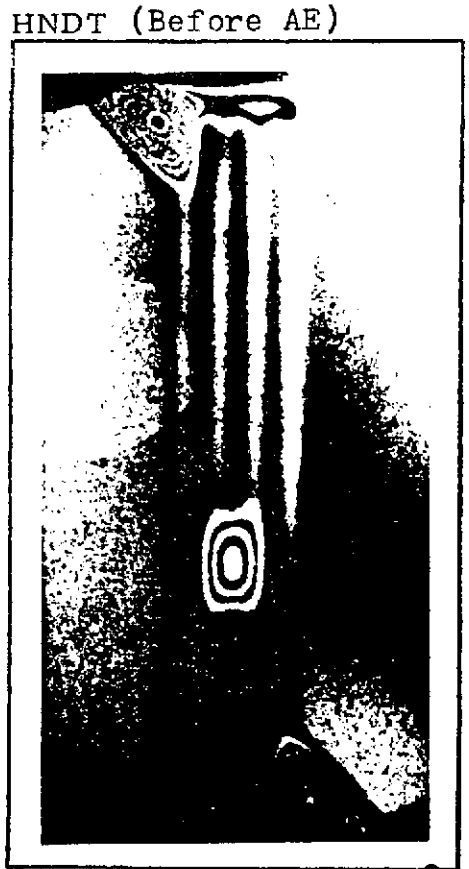
METALLURGICAL ANALYSIS: Not Required.

FIGURE C-21

Panel No. N-58

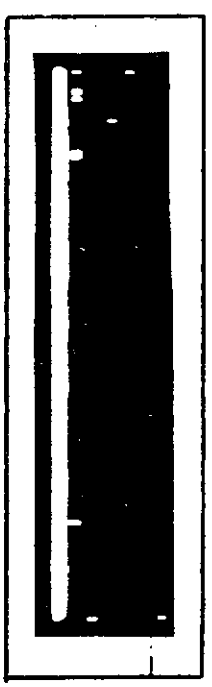


HNDT (Before AE)

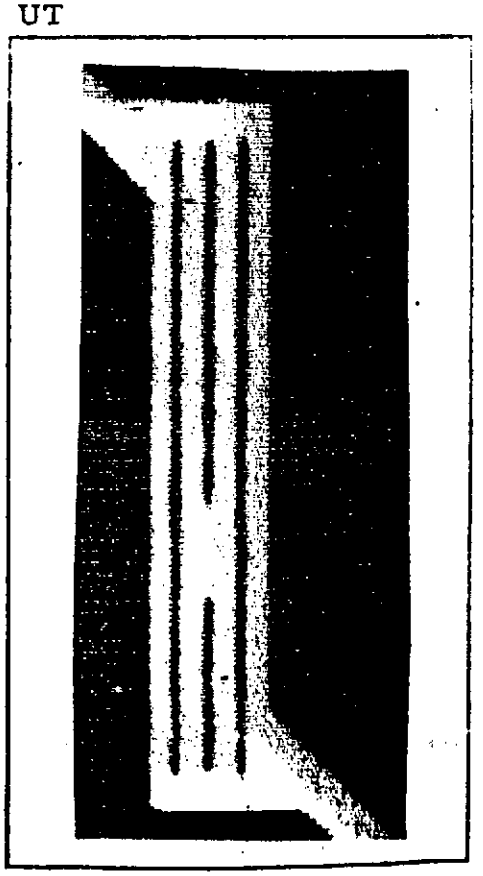


Press. 13.8 x 10^5 N/M^2
(200 PSI)

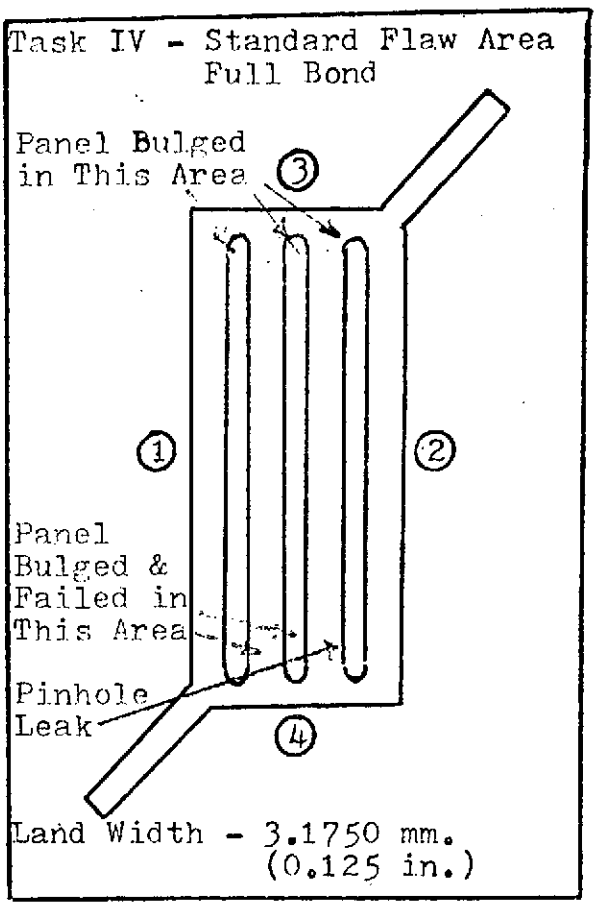
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-08N "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.0757	0.2392
②	6.0579	0.2385
③	6.0503	0.2382
④	6.0503	0.2382

COVERPLATE

MATERIAL: Electroformed Nickel

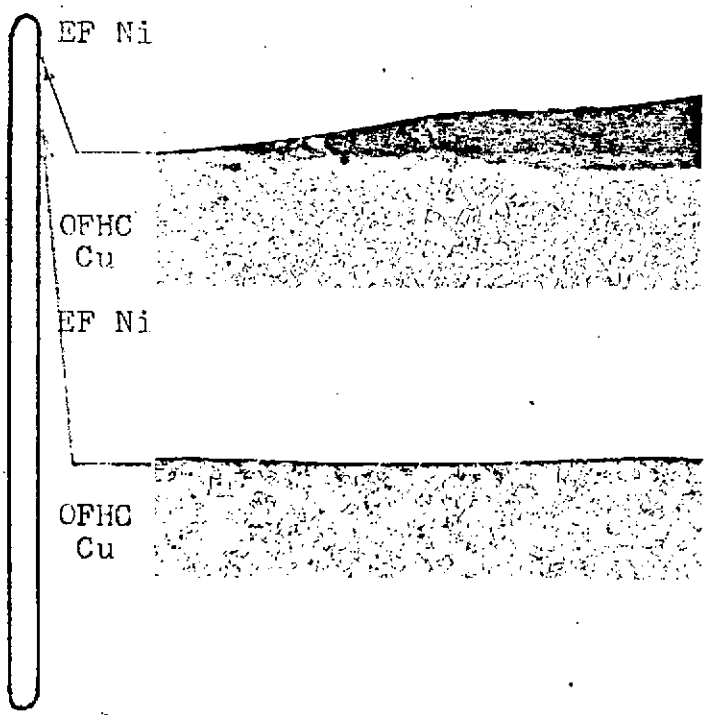
THICKNESS:	MM.	INCHES
①	0.9550	0.0376
②	0.9703	0.0382
③	0.9449	0.0372
④	0.9957	0.0392

PRESSURE REQUIRED TO FAIL BOND:

Bond failure occurred at a pressure of 4.62×10^7 N/m^2 (6,700 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

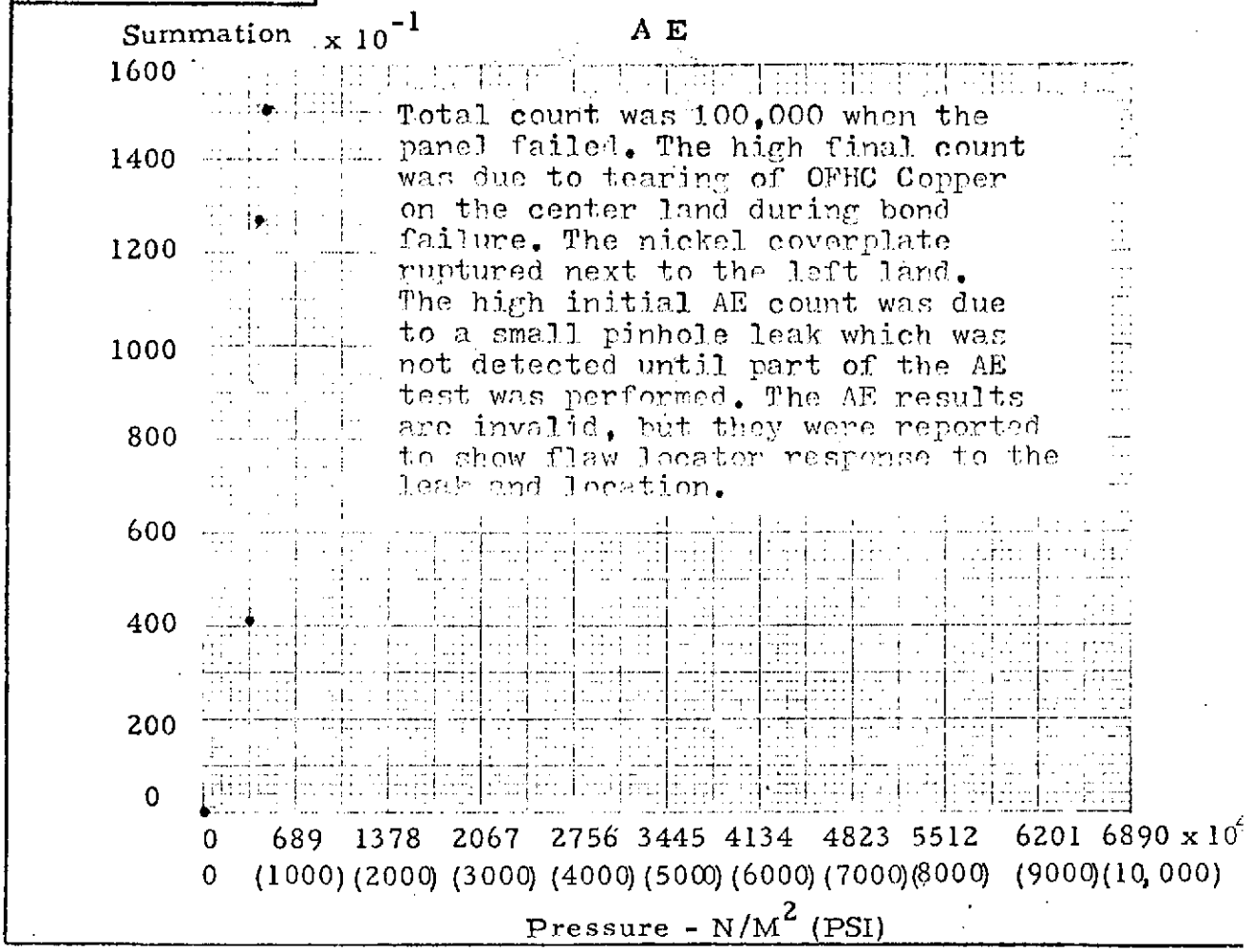


Area of planned full bond showing failure after destructive test. Magnification 50X.

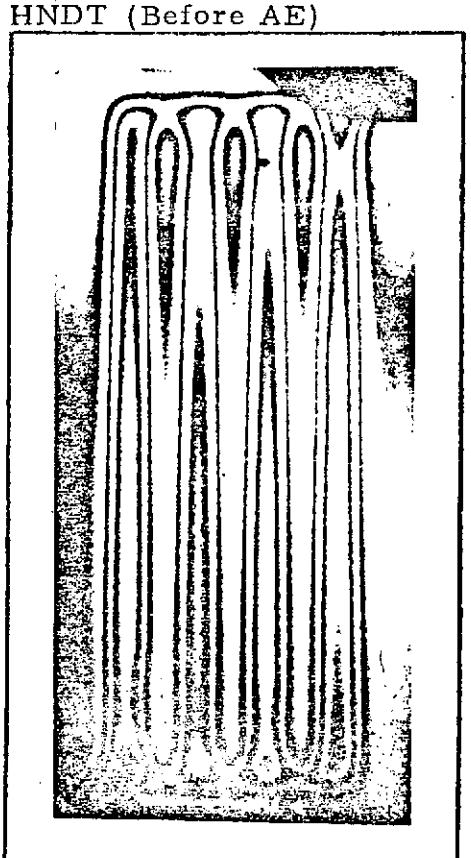
Area of planned full bond next to failed region. No failure noted. Magnification 50X.

FIGURE C-22

Panel No.C-8N"A"

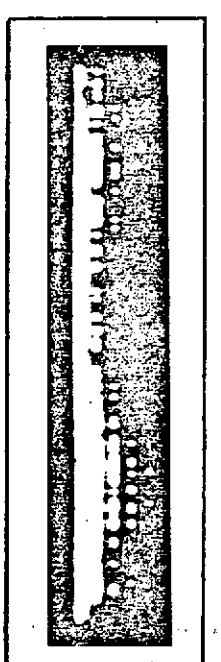


HNDT (Before AE)



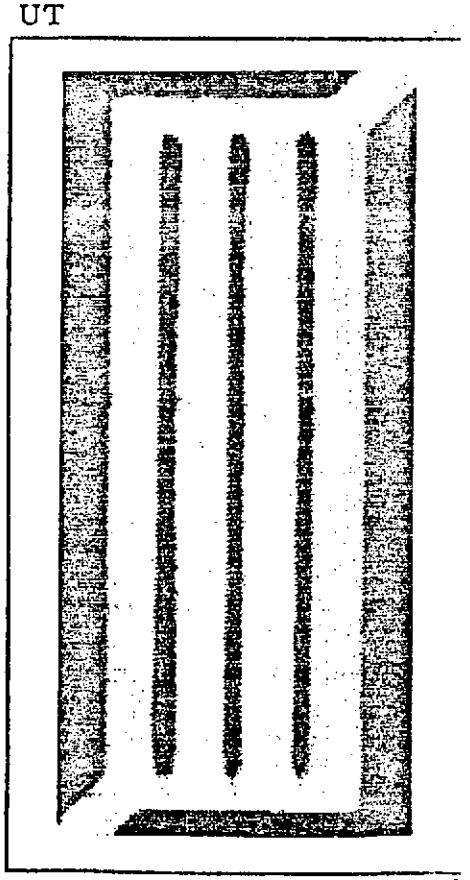
Press. 34.5 x 10^5 N/M^2
(500 PSI)

AE
FLAW LOCATOR
CENTER LAND

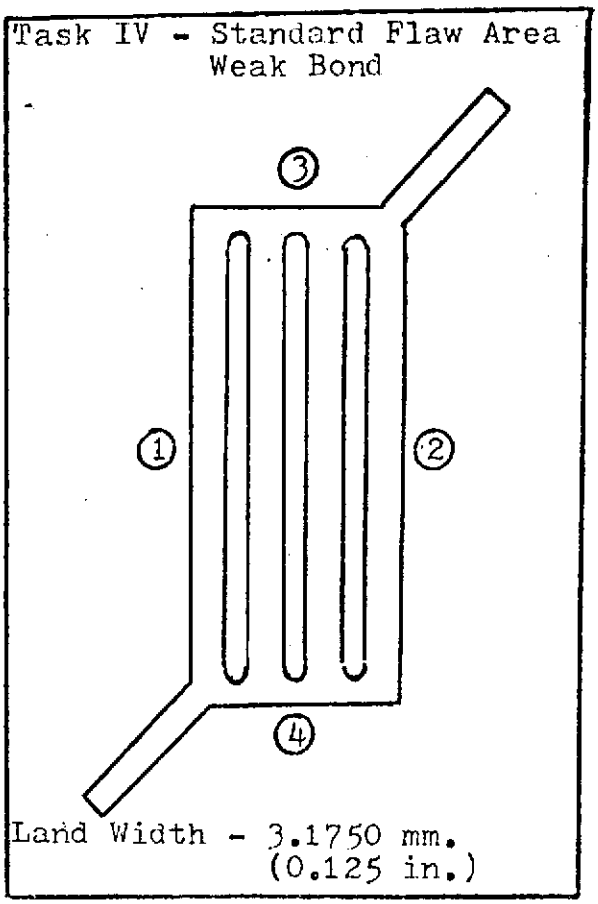


After NDE and
Destructive Test

UT



ELECTROFORMED PANEL NO. C-28N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.6192	0.2606
②	6.6015	0.2599
③	6.6091	0.2602
④	6.5964	0.2597

COVERPLATE

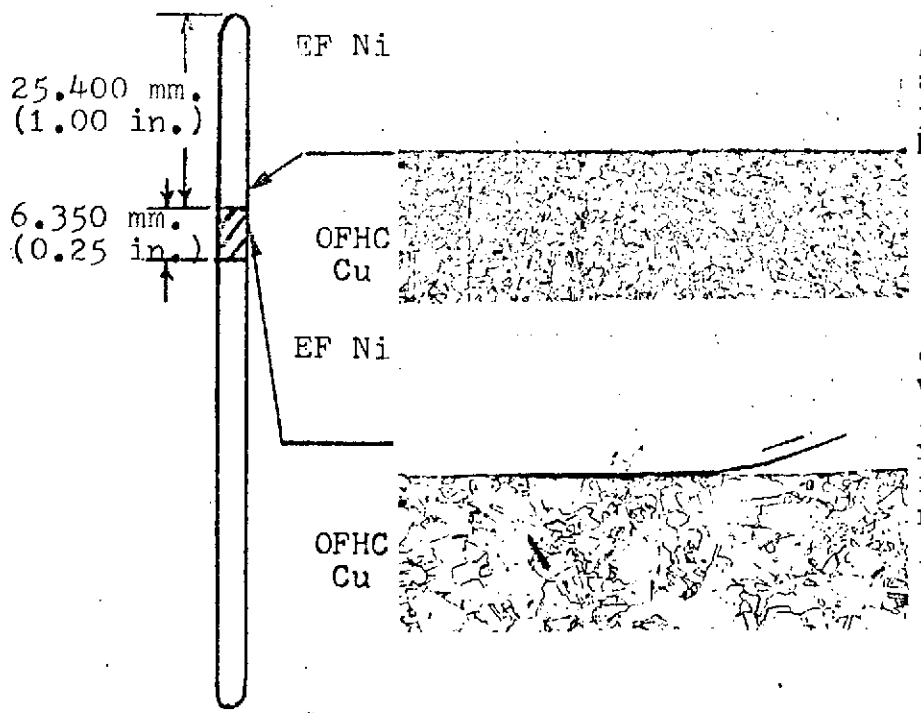
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9601	0.0378
②	0.9754	0.0384
③	0.9525	0.0375
④	0.9601	0.0378

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 5.18×10^7 N/m^2 (7,500 psi)

CENTER LAND DEFECT



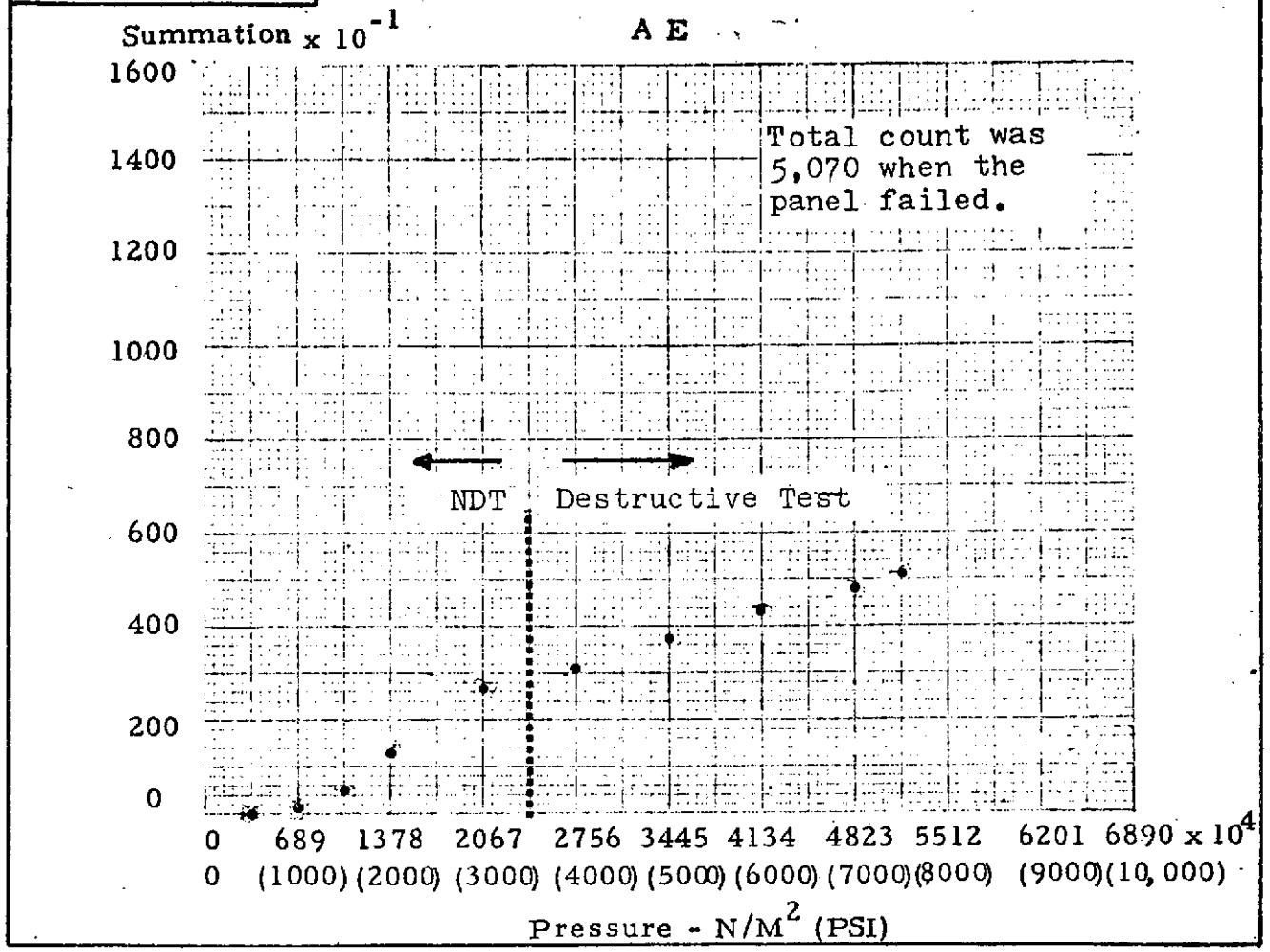
METALLOGRAPHIC ANALYSIS:

Section of full bond area adjacent to the planned weak bond. Magnification 50X.

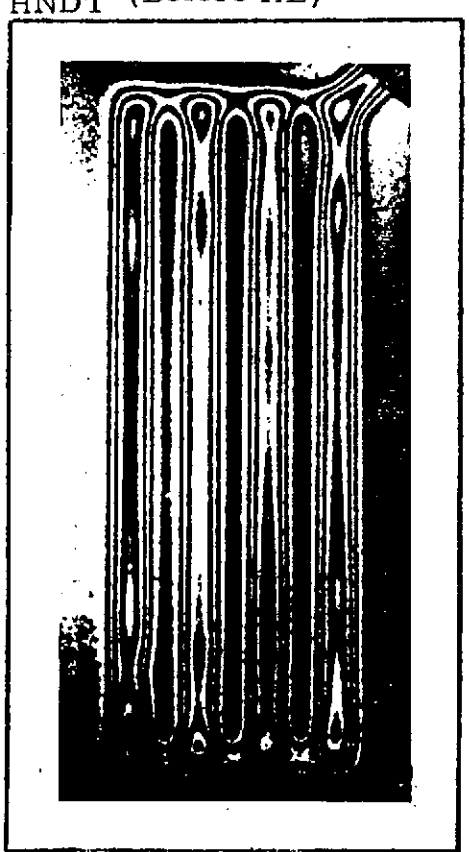
Section of planned weak bond. Preparation of specimen removed most of the failure. Some traces remain. Magnification 50X.

FIGURE C-23

Panel No. C-28N

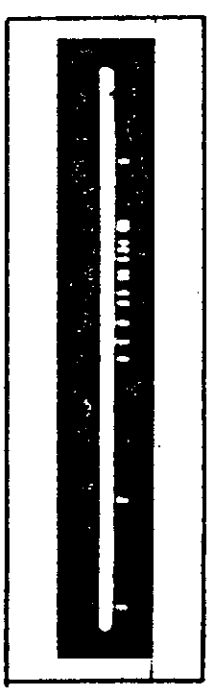


HNDT (Before AE)

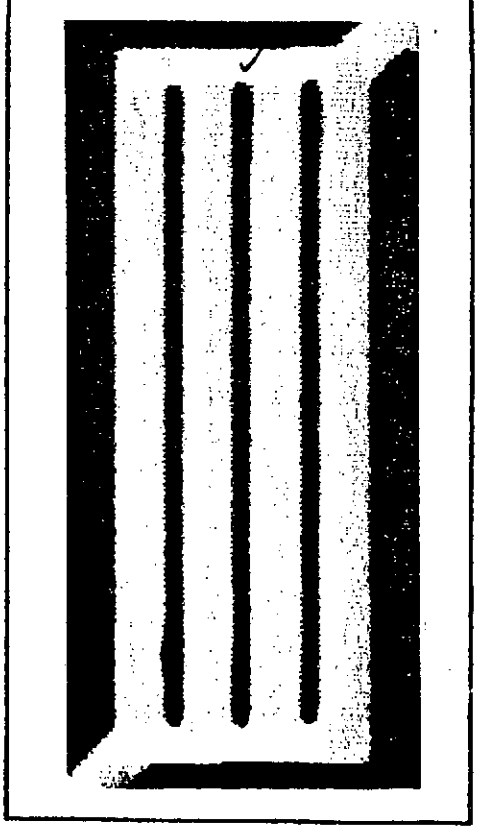


Press. = 13.8 x 10^5 N/M^2
(200 PSI)

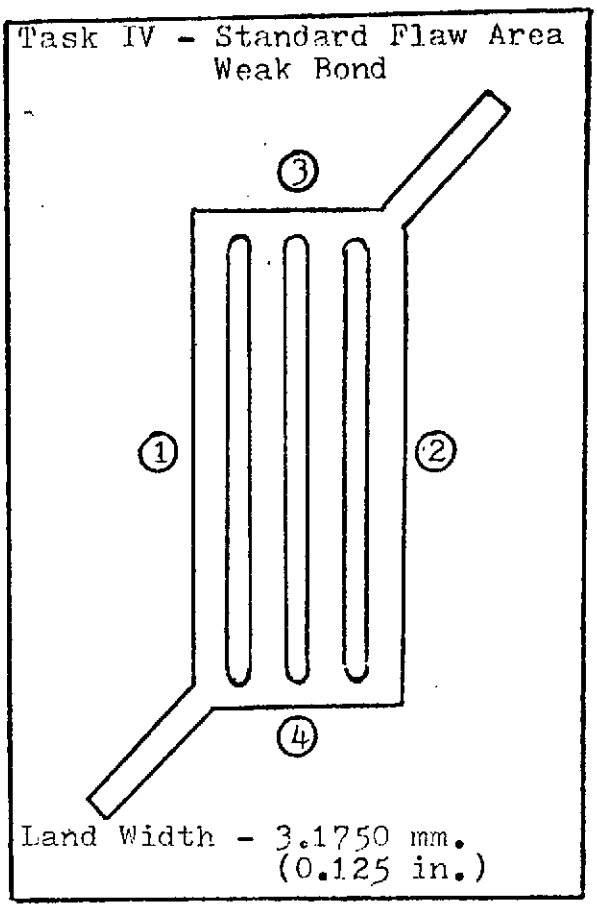
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-29N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION:
0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.4135	0.2525
②	6.3881	0.2515
③	6.4440	0.2537
④	6.3322	0.2493

COVERPLATE

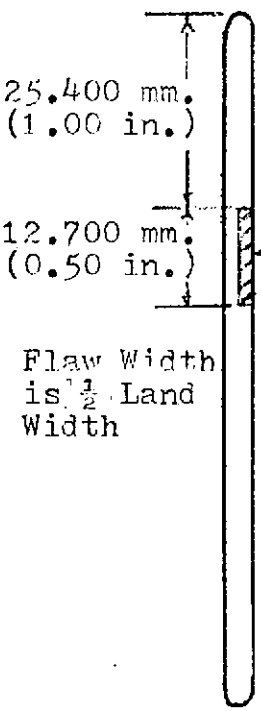
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9525	0.0375
②	0.9779	0.0385
③	0.9017	0.0355
④	1.0160	0.0400

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 5.52×10^7 N/m^2 (8,000 psi)

CENTER LAND DEFECT

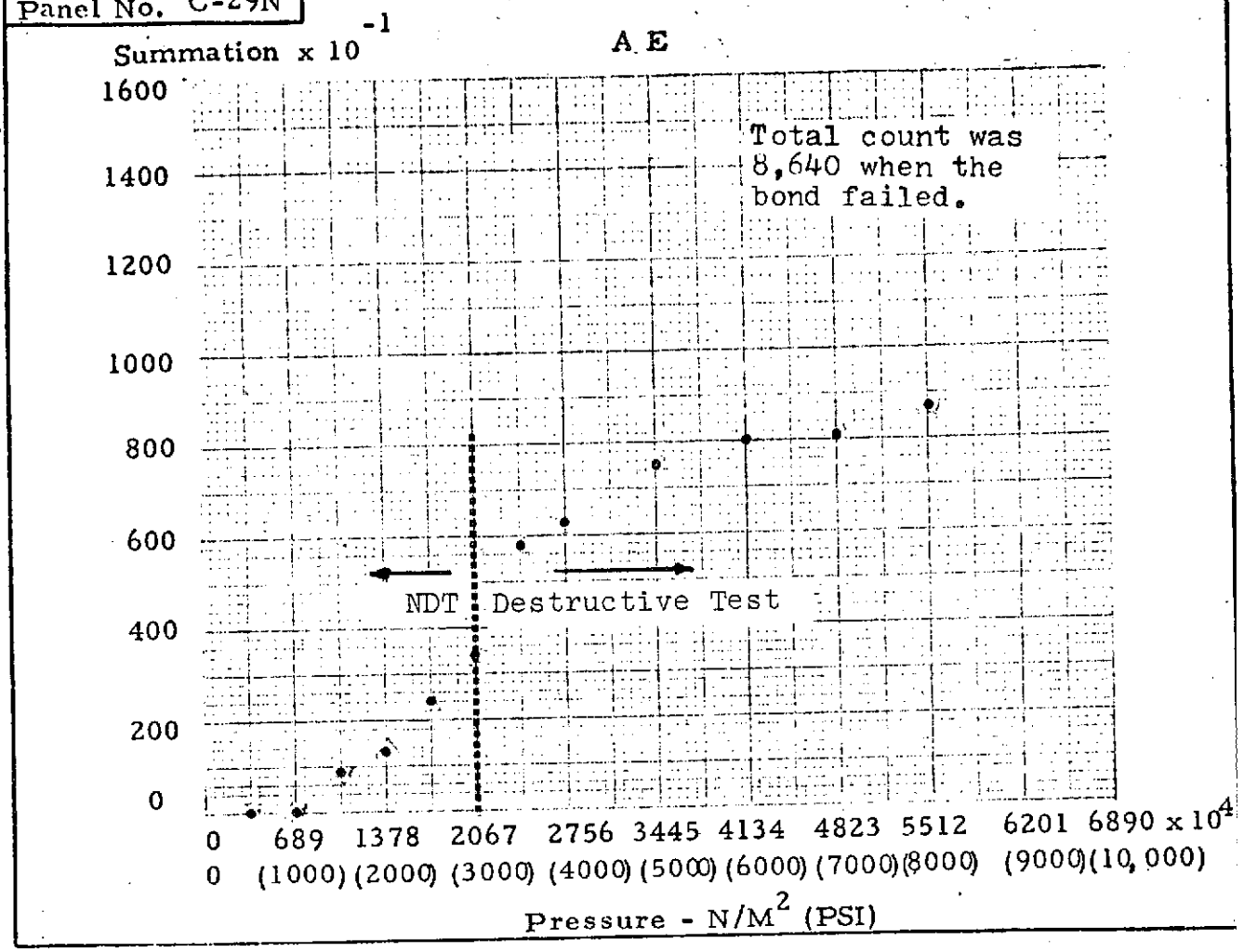


METALLOGRAPHIC ANALYSIS:

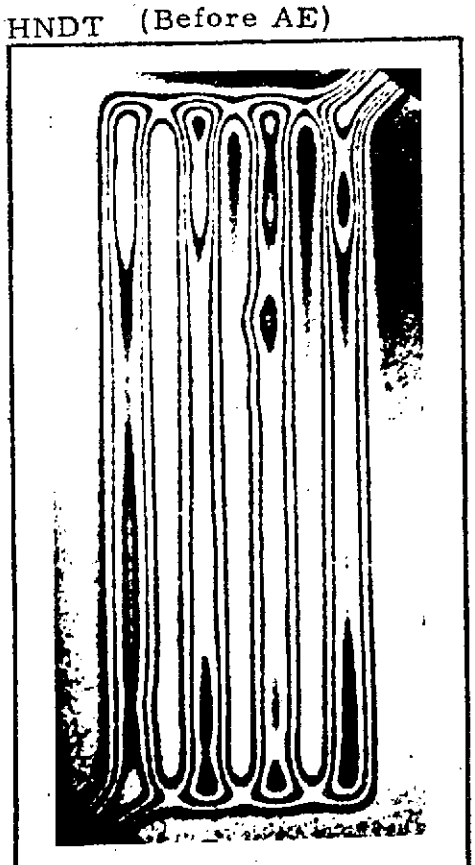
Section of planned ½ land width weak bond. Weak bond, showing failure, appears reversed due to the direction of viewing. The full bond remained intact after pressurization. Magnification 50X.

FIGURE C-24

Panel No. C-29N

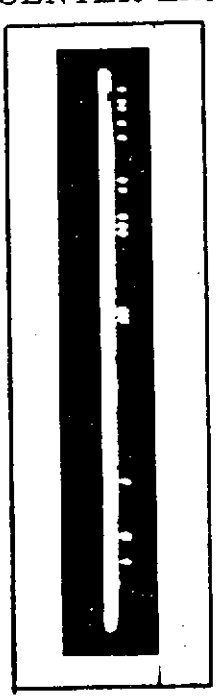


HNDT (Before AE)

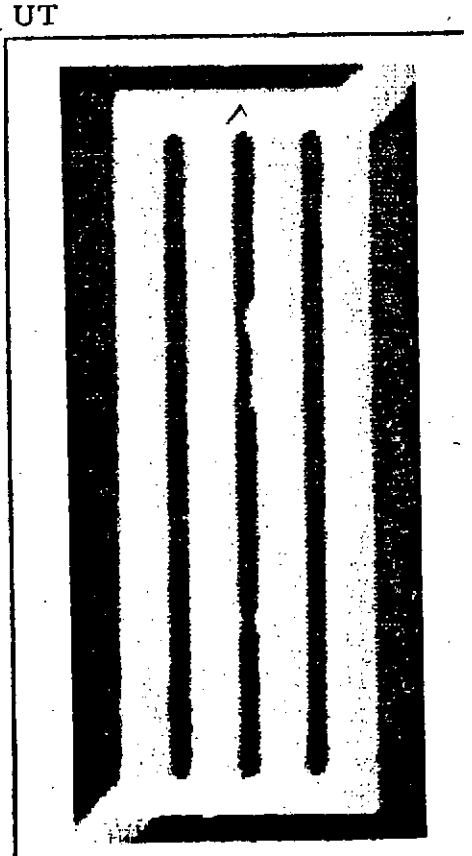


Press. - 13.8 x 10^5 N/M^2
(200 PSI)

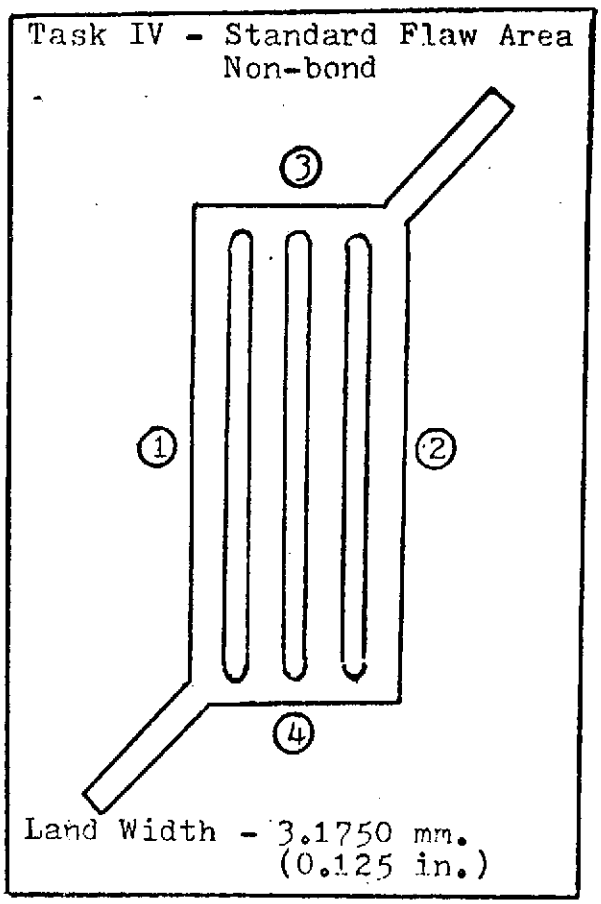
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-30N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION:
0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.5837	0.2592
②	6.5202	0.2567
③	6.5507	0.2579
④	6.5507	0.2579

COVERPLATE

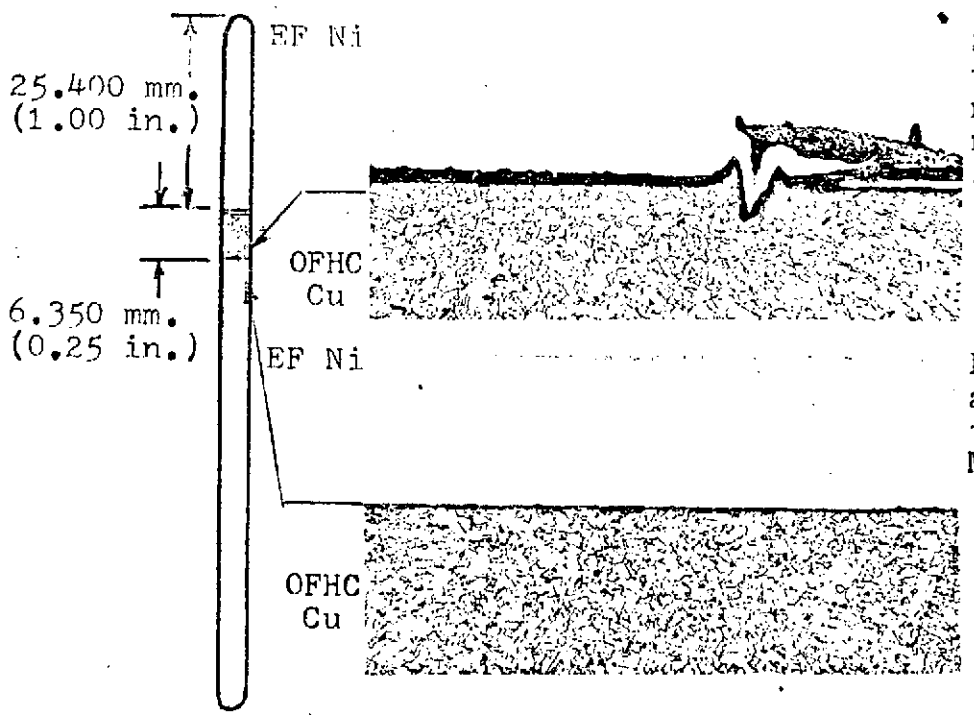
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9068	0.0357
②	0.9271	0.0365
③	0.9296	0.0366
④	0.9144	0.0360

PRESSURE REQUIRED TO FAIL BOND:
Bond failed at a pressure of 2.28×10^7 N/m^2 (3,300 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

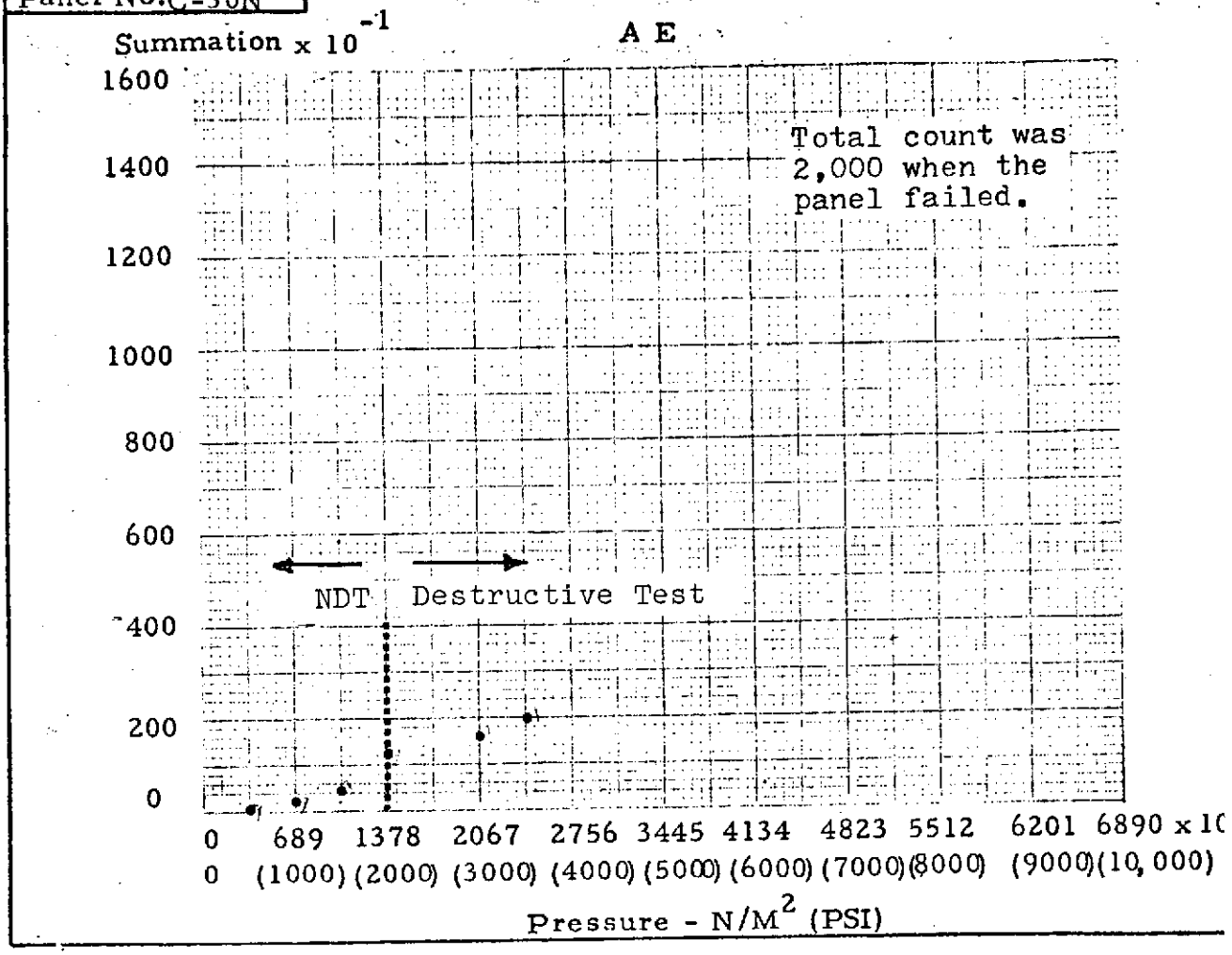


Section showing termination of nonbond as planned. Magnification 50X.

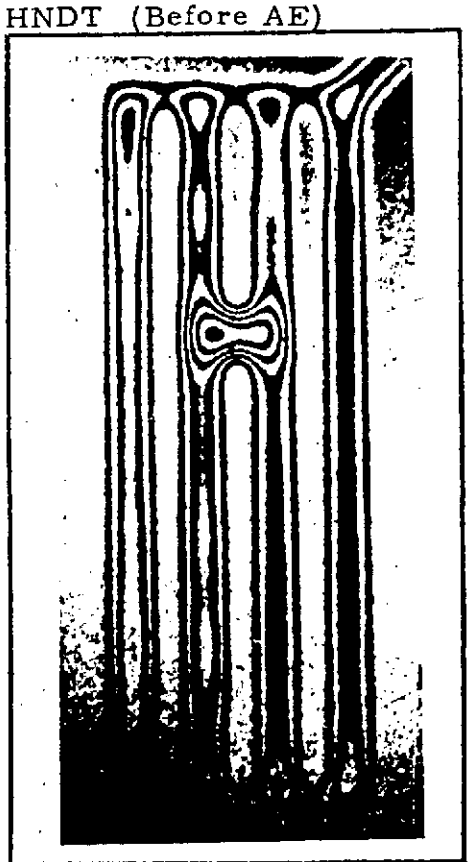
Planned full bond area adjacent to the nonbond. Magnification 50X.

FIGURE C-25

Panel No. C-30N

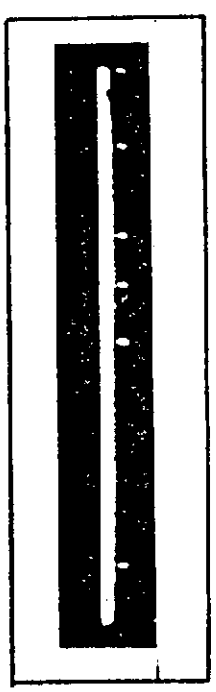


HNDT (Before AE)

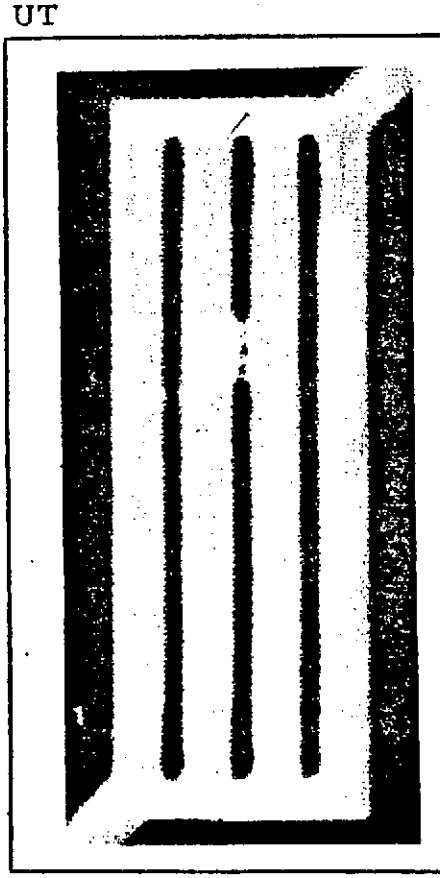


PRESS. - 6.9×10^5 N/M^2 (100 PSI)

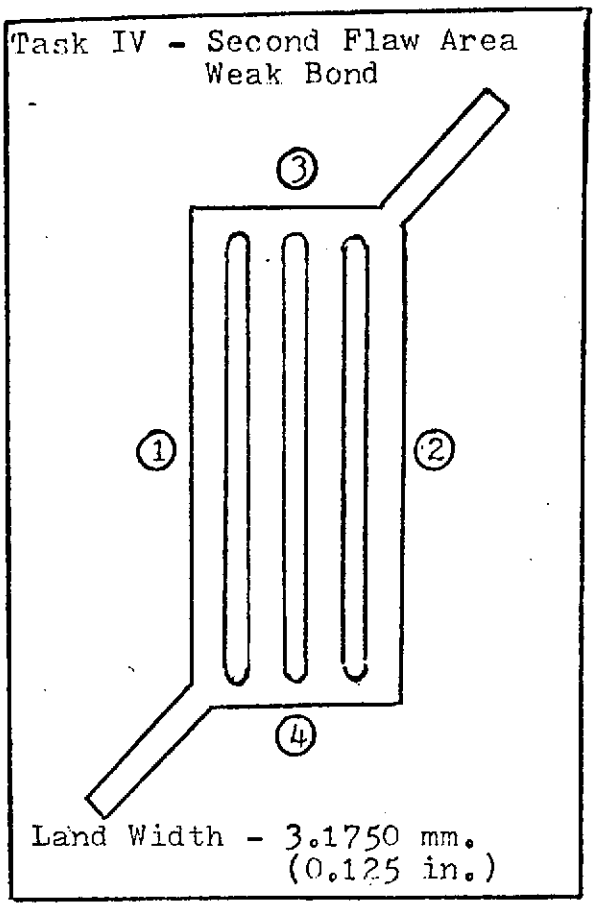
AE FLAW LOCATOR CENTER LAND



UT



ELECTROFORMED PANEL NO. C-32N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.0005 in. (0.0127 mm.)

THICKNESS:	MM.	INCHES
①	6.5608	0.2583
②	6.5837	0.2592
③	6.5456	0.2577
④	6.5583	0.2582

COVERPLATE

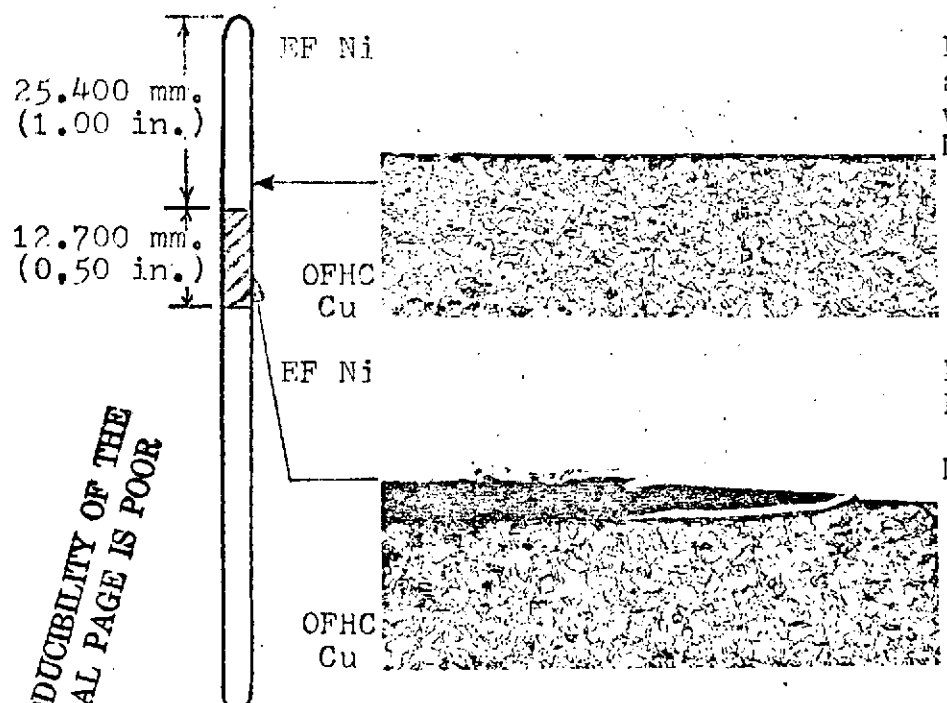
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9652	0.0380
②	0.9068	0.0357
③	0.9601	0.0378
④	0.9296	0.0366

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.76×10^7 N/m^2 (4,000 psi)

CENTER LAND DEFECT



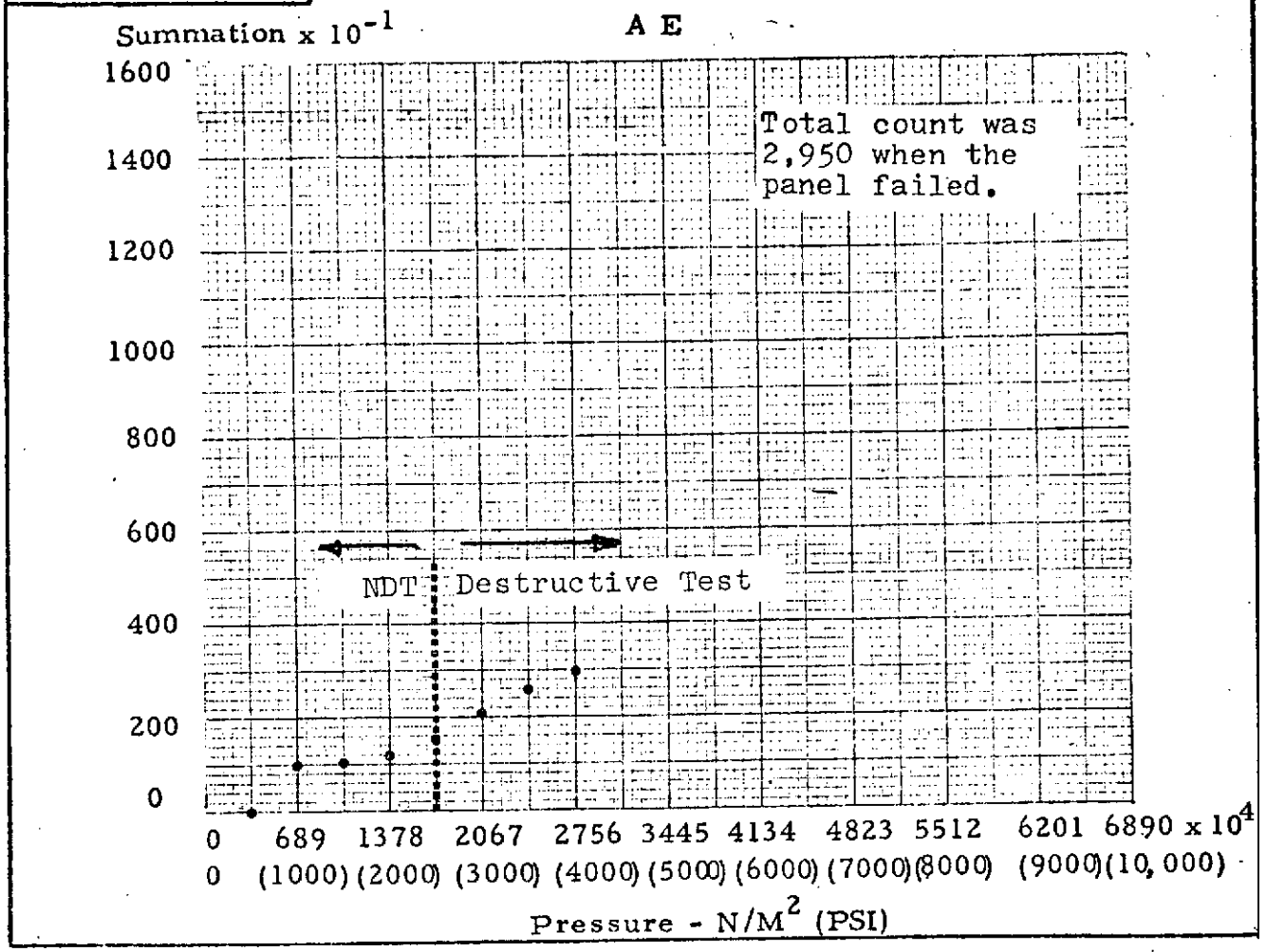
METALLOGRAPHIC ANALYSIS:

Planned full bond adjacent to the weak bond region. Magnification 50X.

Planned weak bond. Failure occurred in this area. Magnification 50X.

FIGURE C-26

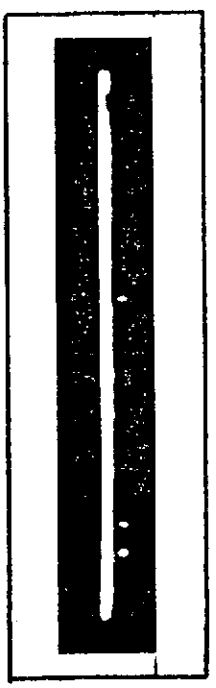
Panel No. C-32N



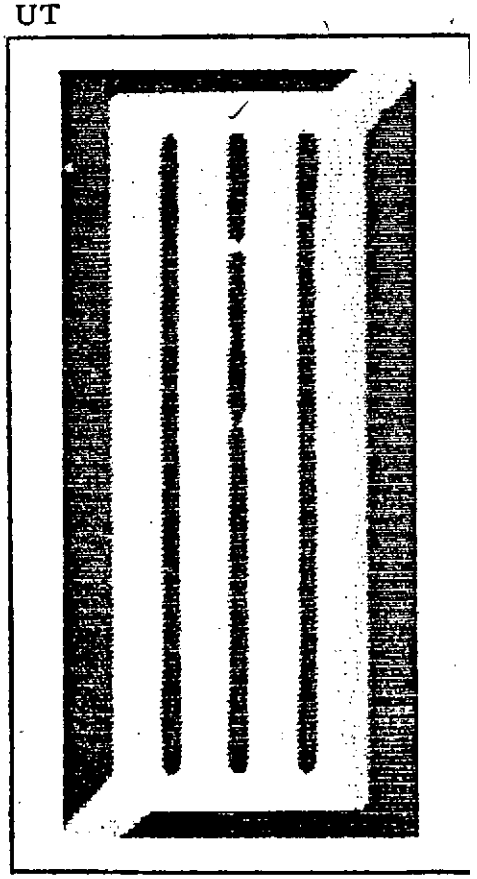
HNDT (Before AE)

Press. ~~13.~~ 8 x 10^5 N/M^2
(200 PSI)

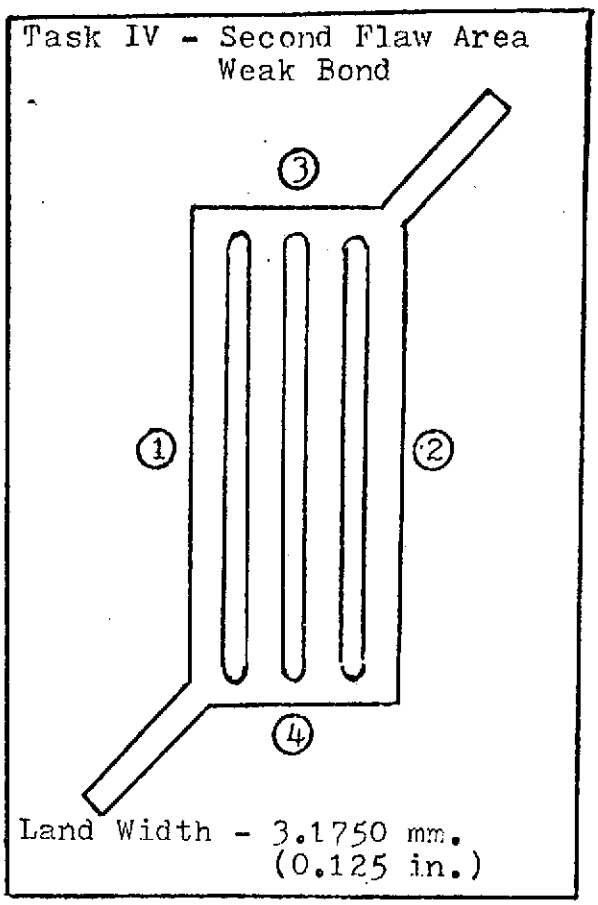
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-33N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.0005 in. (0.0127 mm.)

THICKNESS:	MM.	INCHES
①	6.5938	0.2596
②	6.6142	0.2604
③	6.6065	0.2601
④	6.5862	0.2593

COVERPLATE

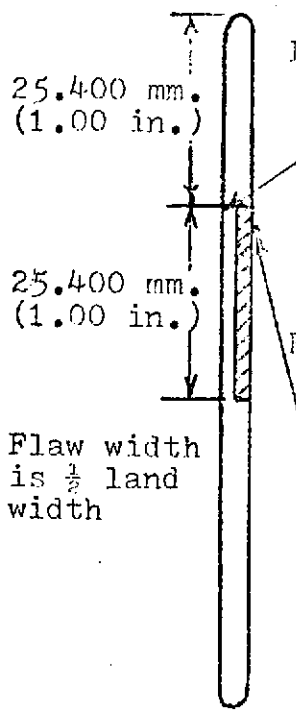
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.8814	0.0347
②	0.8992	0.0354
③	0.8814	0.0347
④	0.9144	0.0360

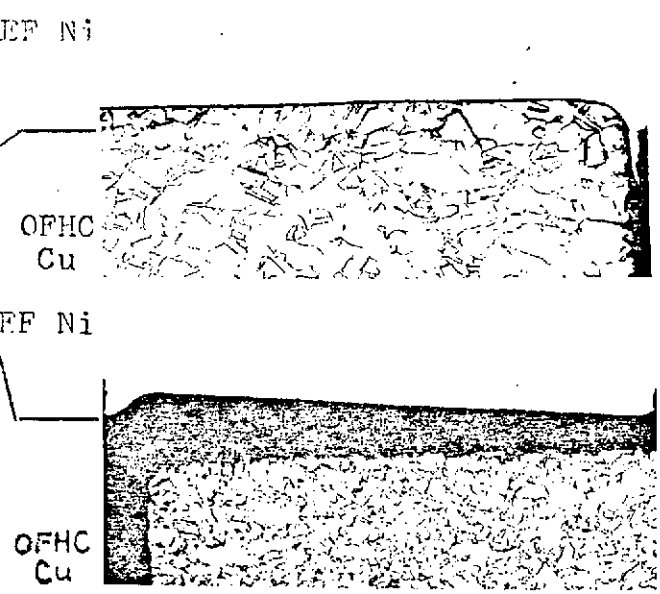
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 5.18×10^7 N/m^2 (7,500 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

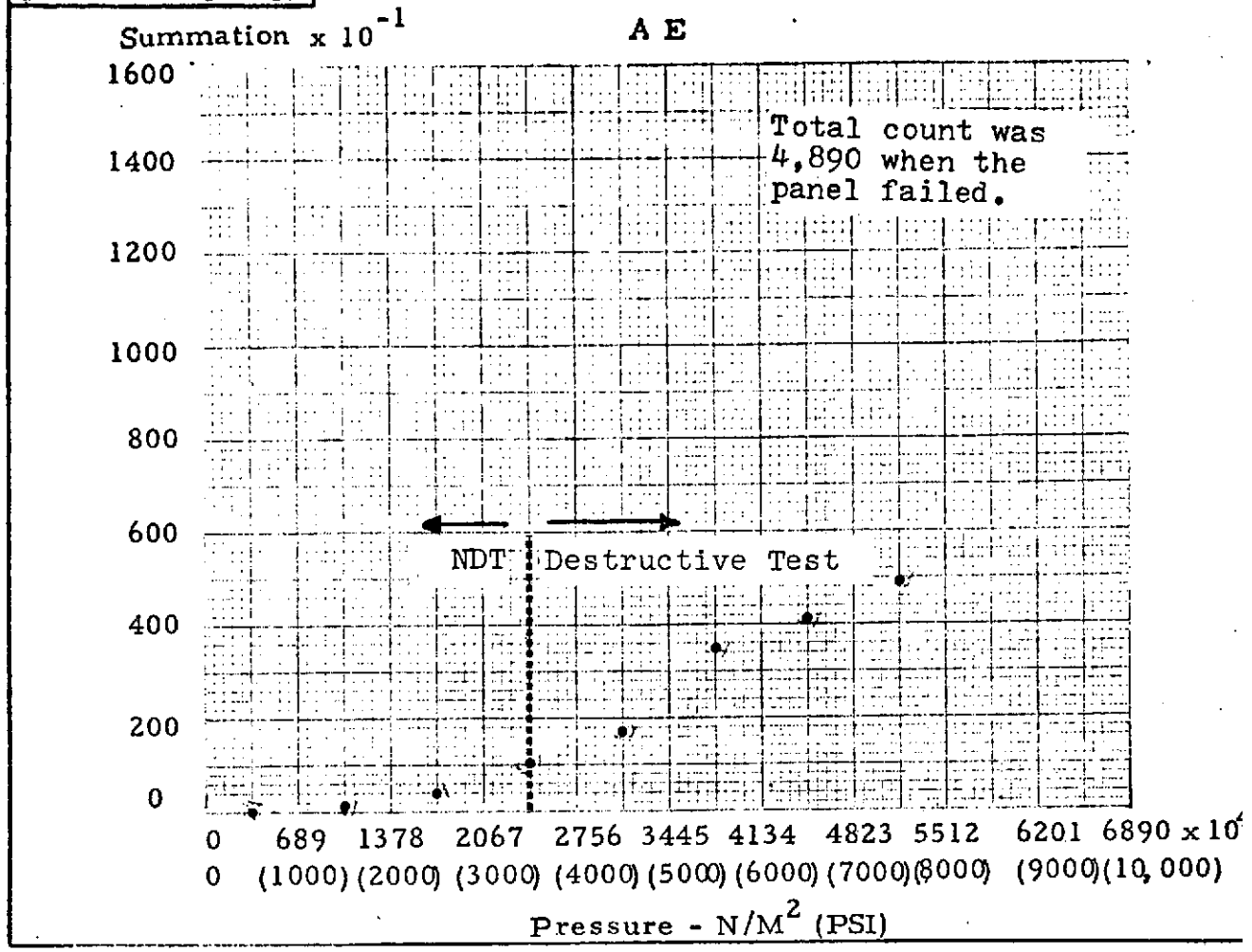


Full bond area next to planned weak bond. View appears reversed due to viewing direction. Magnification 50X.

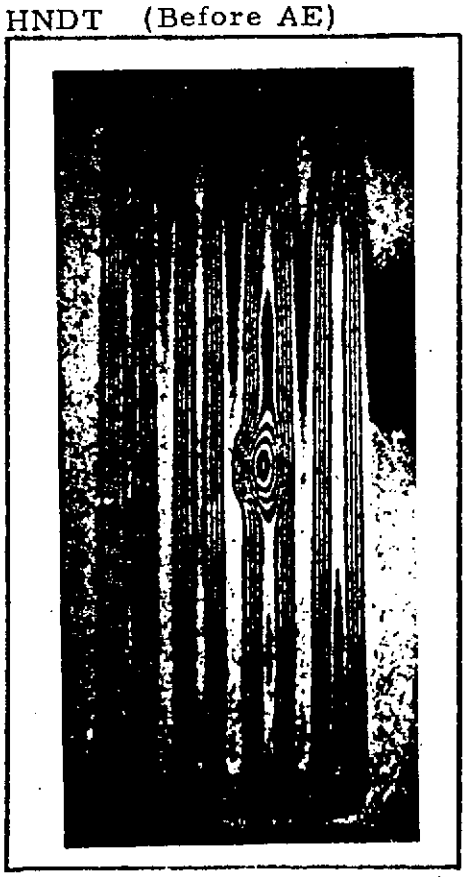
Planned weak bond showing bond failure. Section appears reversed due to direction of viewing. Magnification 50X.

FIGURE C-27

Panel No. C-33N

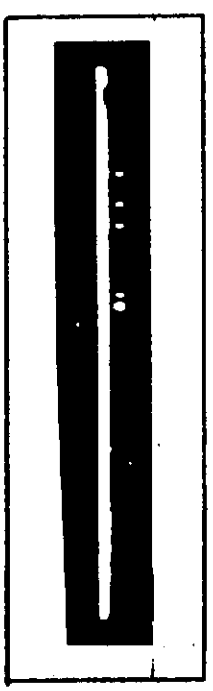


HNDT (Before AE)

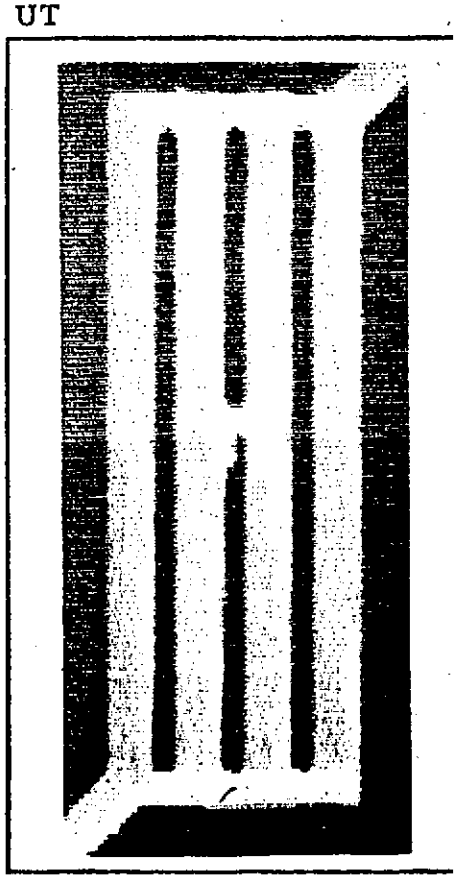


Press. - 20.7×10^5 N/M^2
(50 PSI)

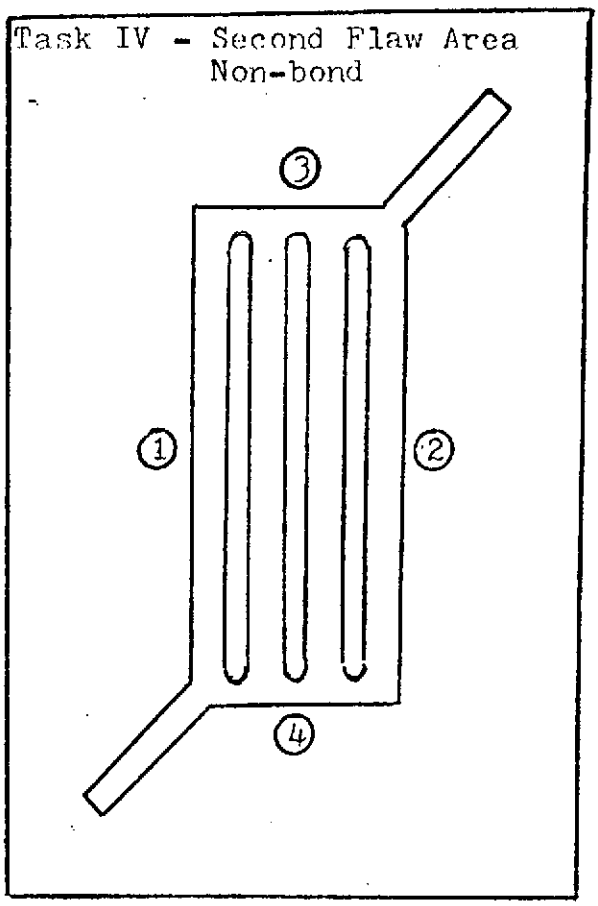
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-34N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.0025 in. (0.0635 mm.)

THICKNESS:	MM.	INCHES
①	6.4846	0.2553
②	6.4821	0.2552
③	6.4541	0.2541
④	6.5126	0.2564

COVERPLATE

MATERIAL: Electroformed Nickel

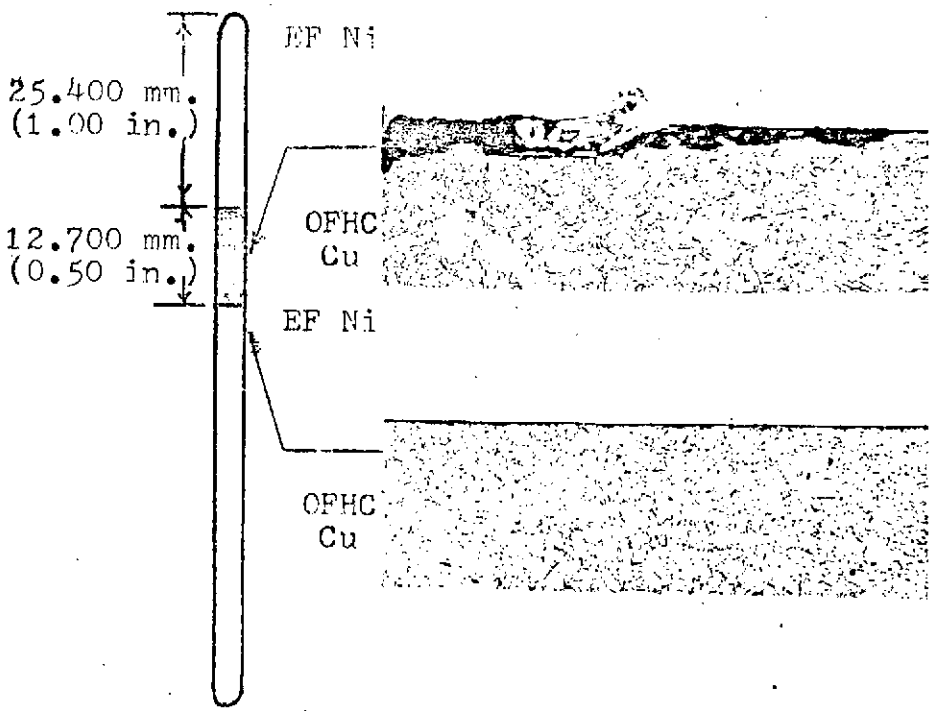
THICKNESS:	MM.	INCHES
①	0.9830	0.0387
②	0.9601	0.0378
③	1.0084	0.0397
④	0.9296	0.0366

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 3.11×10^7 N/m^2 (4,500 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

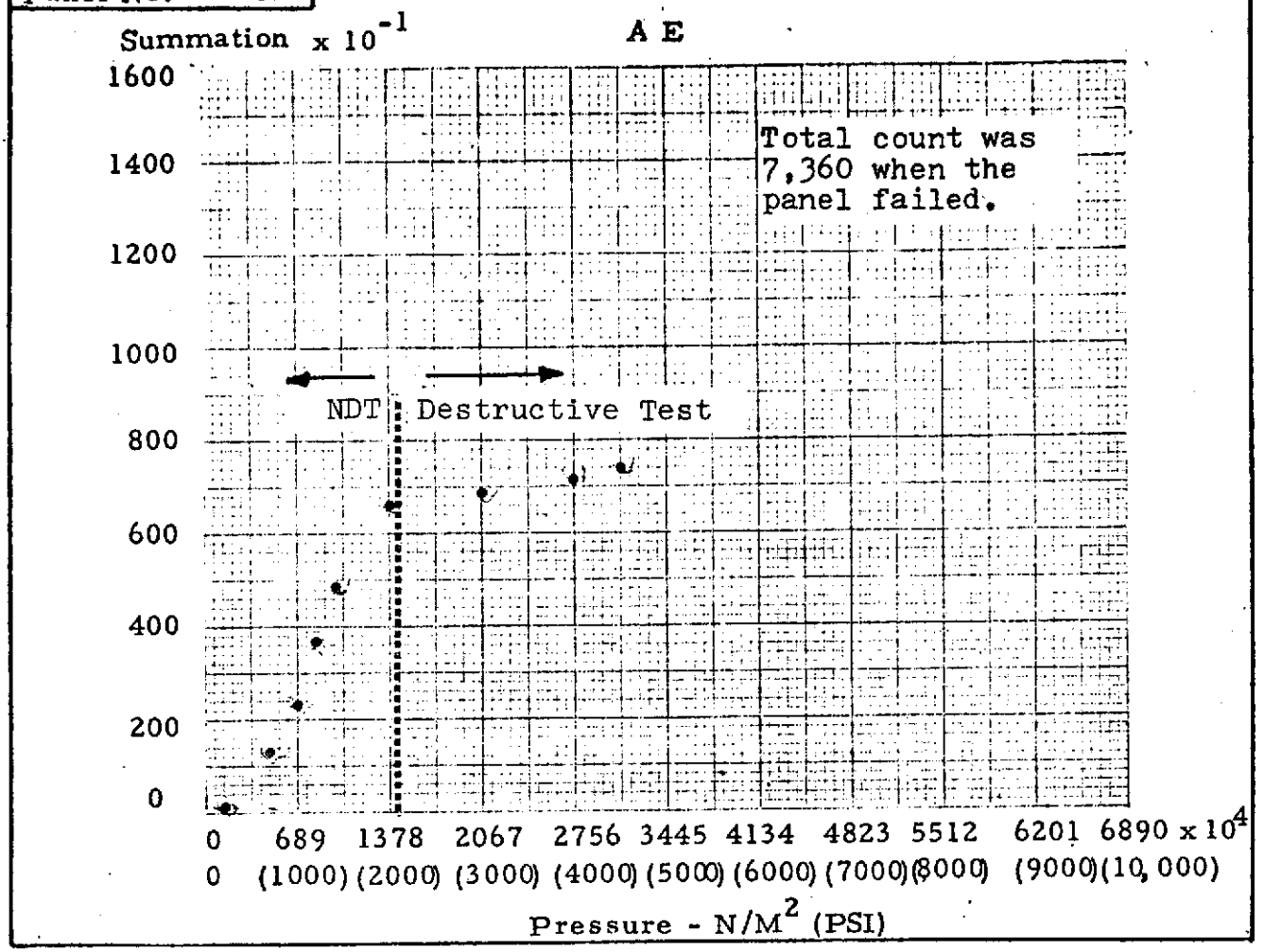


Section showing separation of the planned nonbond. Some full bond failed beyond the end of the nonbond. Magnification 50X.

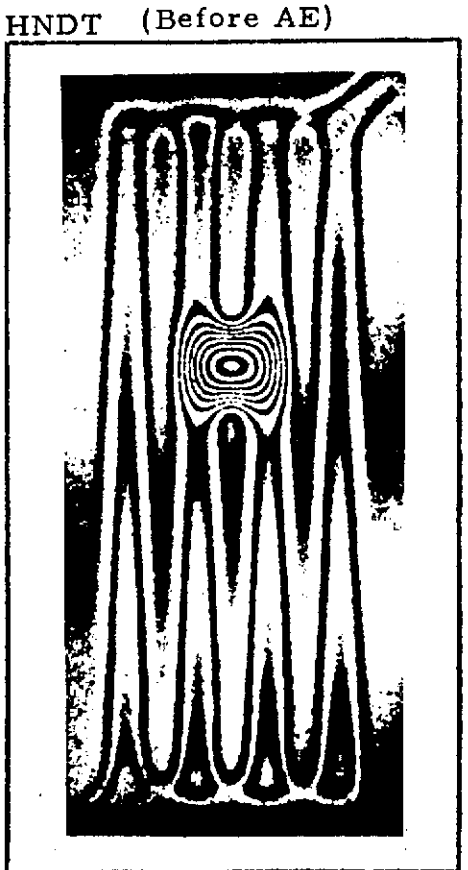
Section of full bond from the middle land which exhibited no failure. Magnification 50X.

FIGURE C-28

Panel No. C-34N

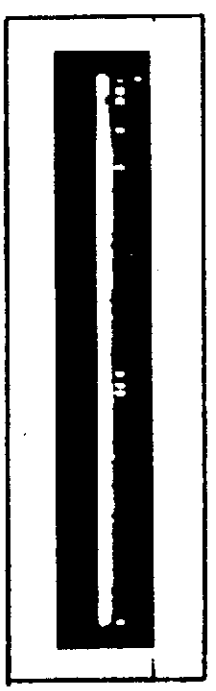


HNDT (Before AE)

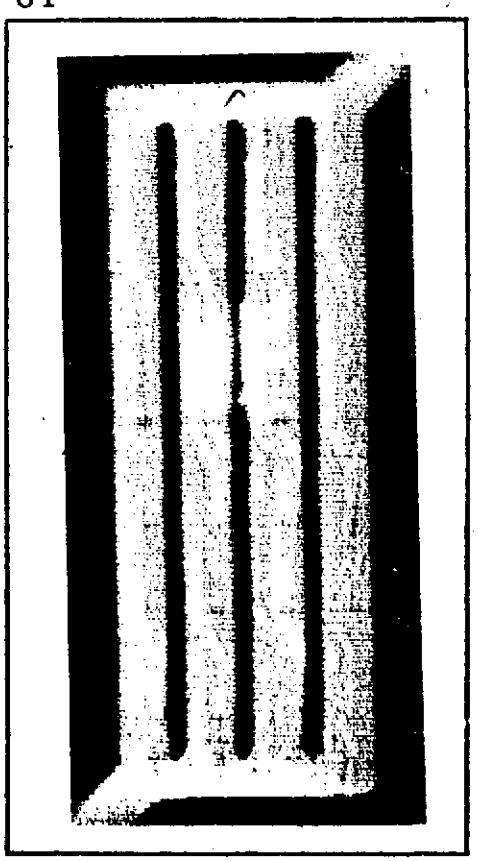


Press. - 3.45 x 10^5 N/M^2
(50 PSI)

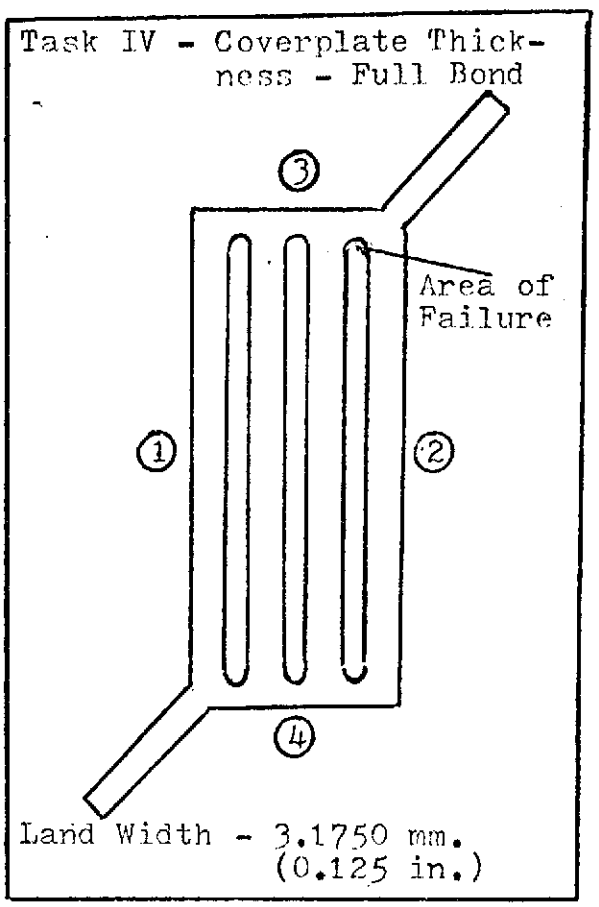
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-09N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.6726	0.2627
②	6.6751	0.2628
③	6.6548	0.2620
④	6.6548	0.2620

COVERPLATE

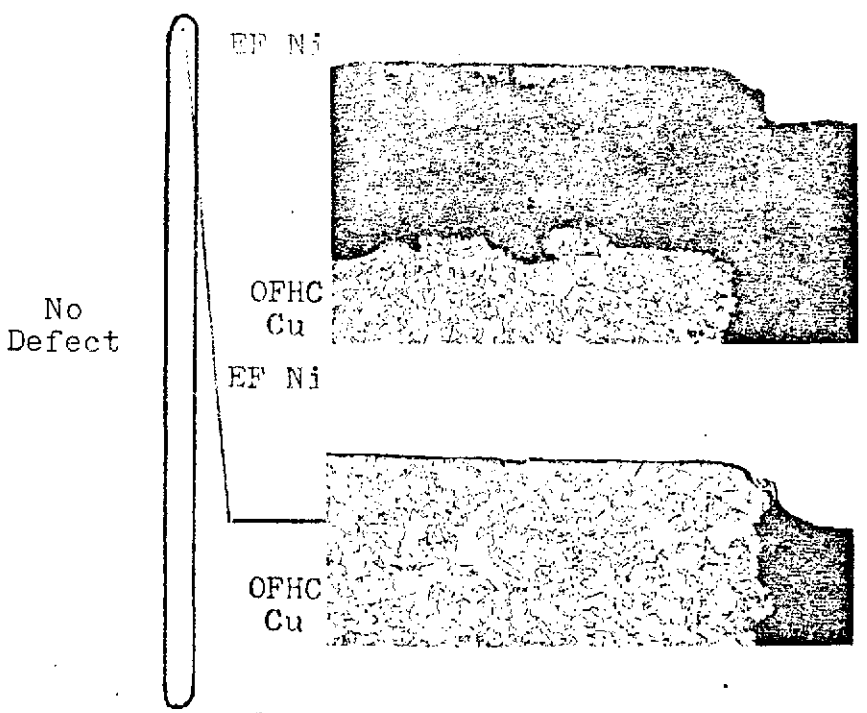
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.6985	0.0275
②	0.6833	0.0269
③	0.7671	0.0302
④	0.6807	0.0268

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 3.45×10^7 N/m^2 (5,000 psi).

CENTER LAND DEFECT



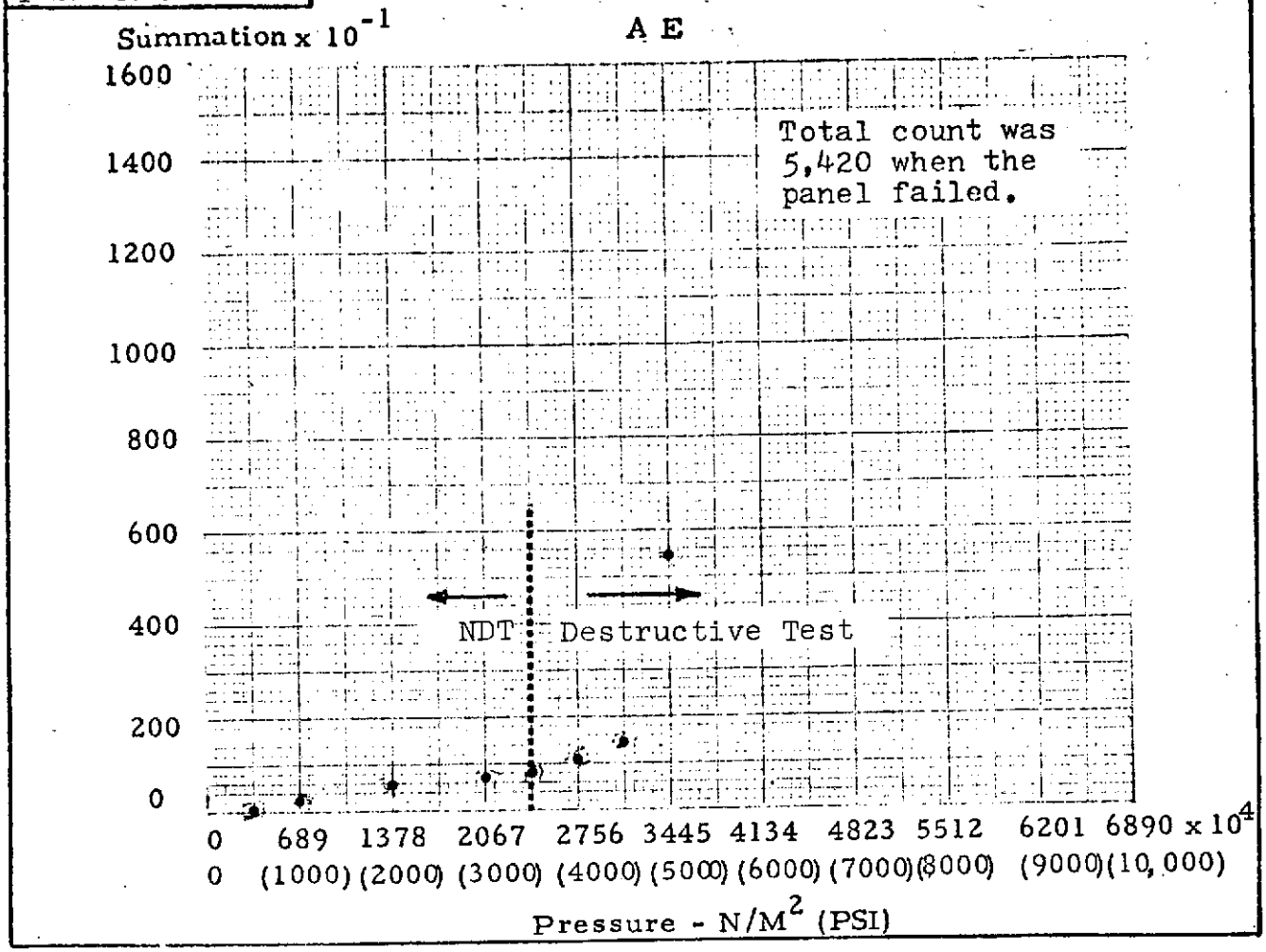
METALLOGRAPHIC ANALYSIS:

Full bond failure section from top end of Land 3. Magnification 50X.

Full bond area which did not fail. Magnification 50X.

FIGURE C-29

Panel No. C-9N

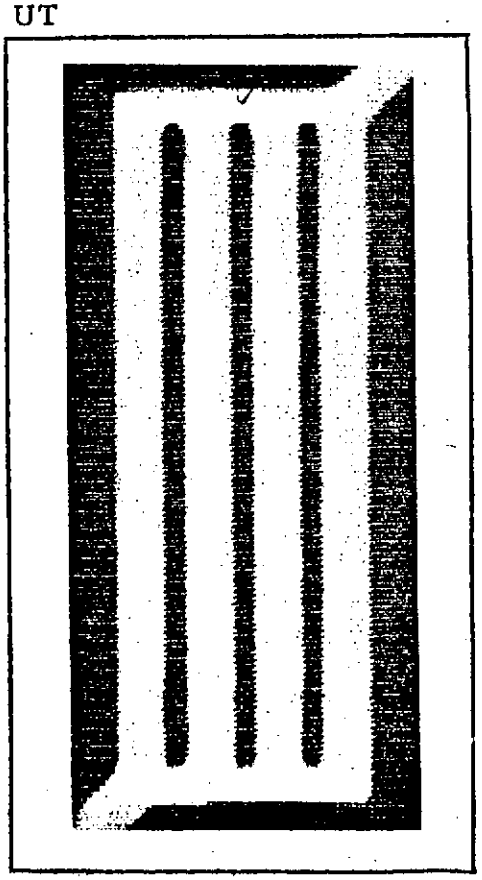


HNDT (Before AE)

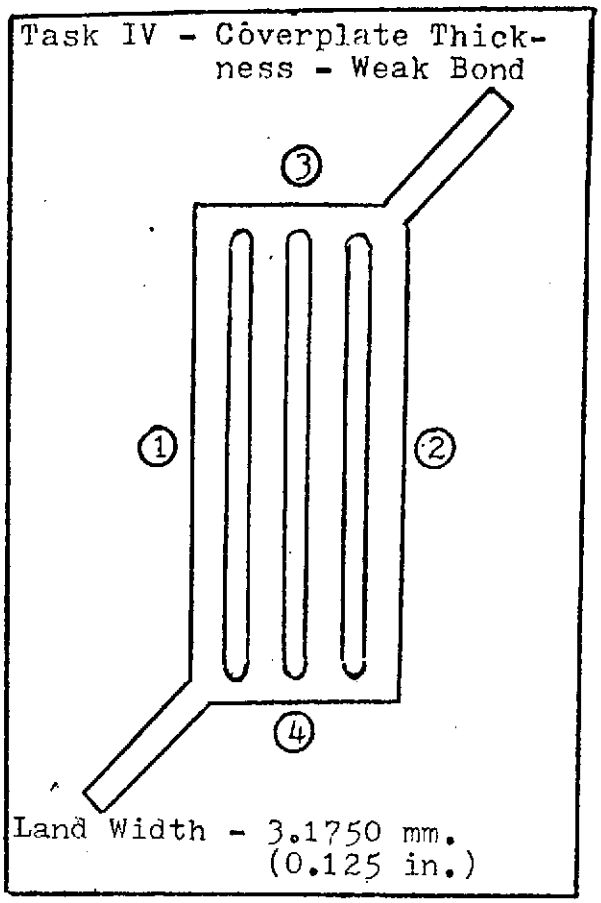
Press. - 20.7 x 10^5 N/M^2
(300 PSI)

AE
FLAW LOCATOR
CENTER LAND

UT



ELECTROFORMED PANEL NO. C-35N "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: ±0.0025 in. (0.0635 mm.)

THICKNESS:	MM.	INCHES
①	6.5100	0.2563
②	6.5227	0.2568
③	6.5659	0.2585
④	6.5354	0.2573

COVERPLATE

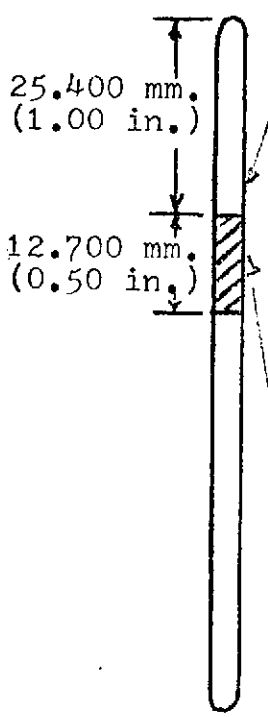
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.6452	0.0254
②	0.6731	0.0265
③	0.6401	0.0252
④	0.5918	0.0233

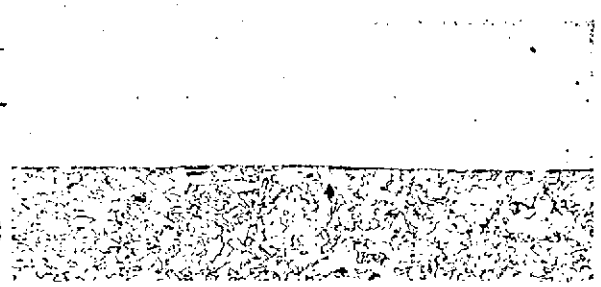
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.42×10^7 N/m^2 (3,500 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

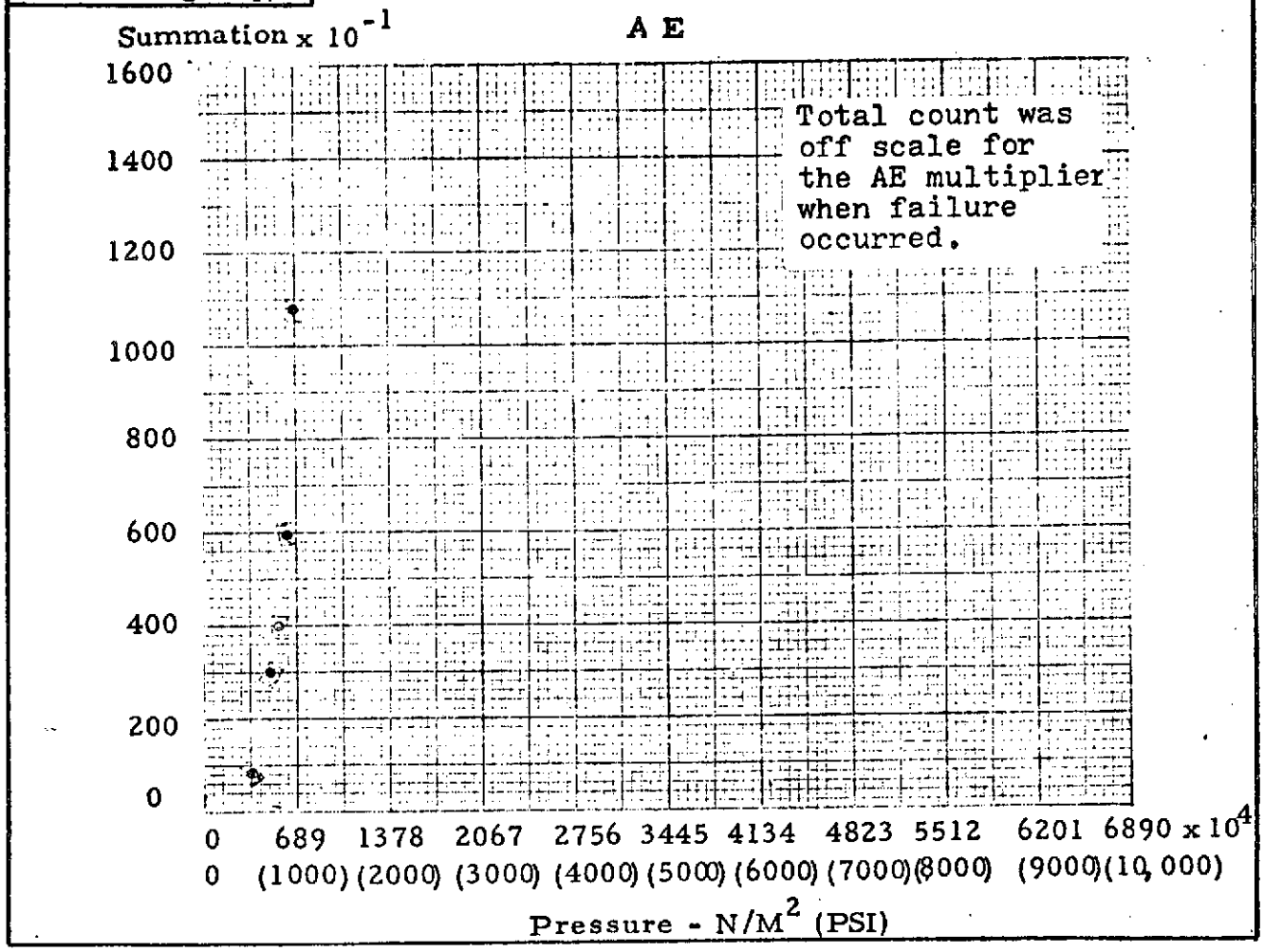


Planned full bond showing no failure after destructive test. Magnification 50X.

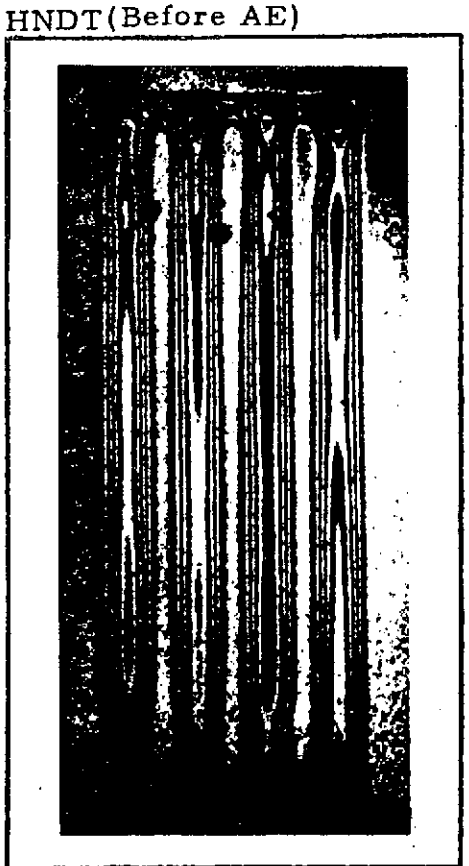
Planned weak bond which failed in destructive test. Magnification 50X.

FIGURE C-30

Panel No. C-35N

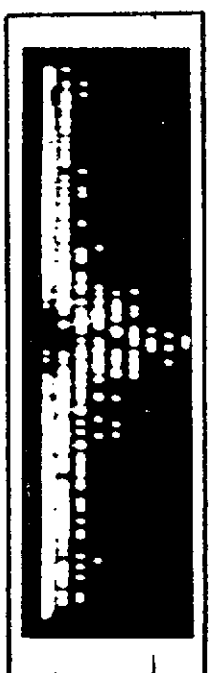


HNDT (Before AE)



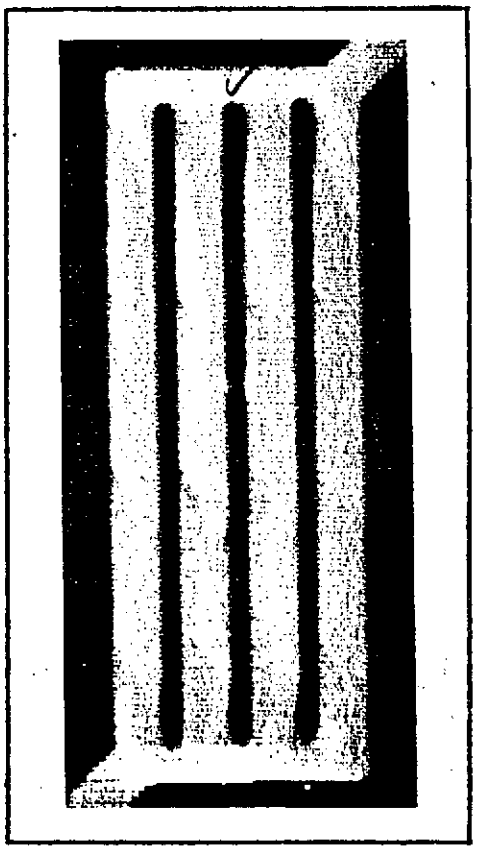
Press. 6.9×10^5 N/M^2
(100 PSI)

AE
FLAW LOCATOR
CENTER LAND

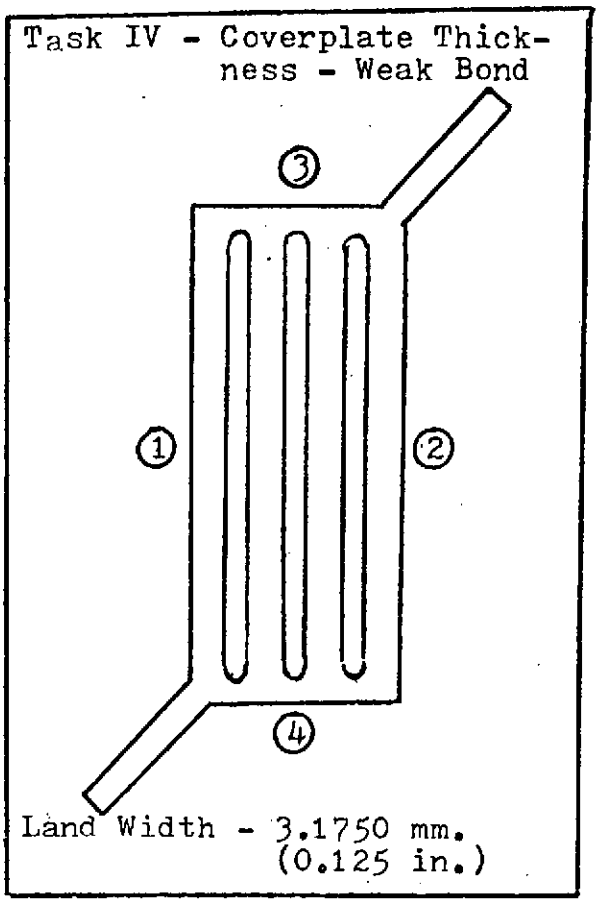


After NDE and
Destructive Test

UT



ELECTROFORMED PANEL NO. C-36N "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.006 in. (0.1524 mm.)

THICKNESS:	MM.	INCHES
①	6.3551	0.2502
②	6.3094	0.2484
③	6.3754	0.2510
④	6.3703	0.2508

COVERPLATE

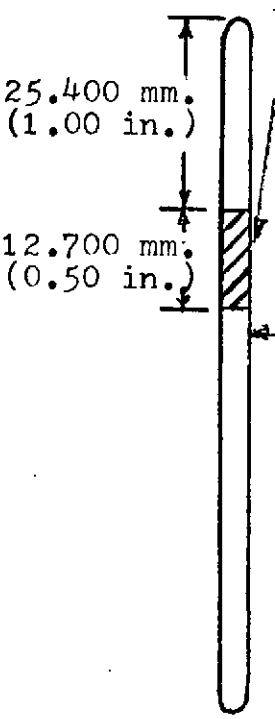
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.7925	0.0312
②	0.8306	0.0327
③	0.7239	0.0285
④	0.7391	0.0291

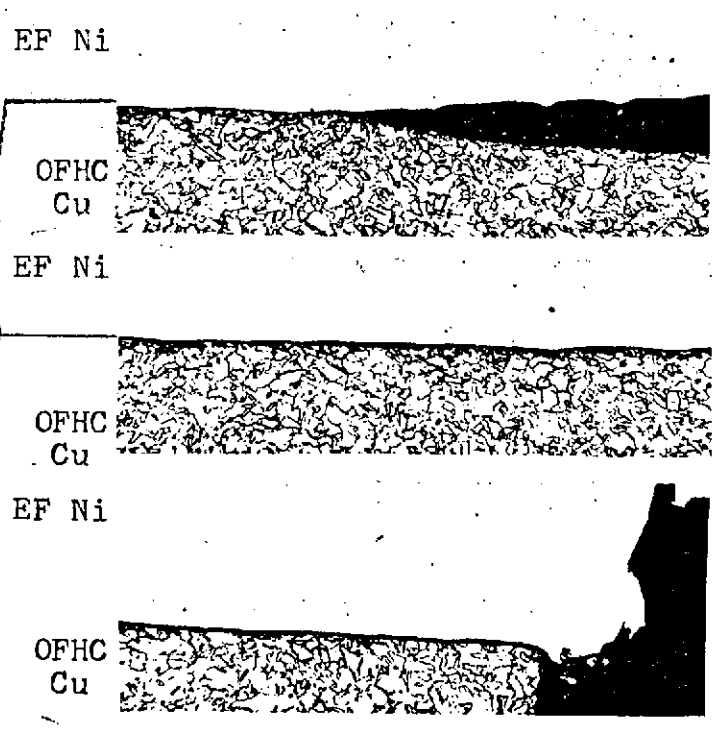
PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 1.86×10^7 N/m^2 (2,700 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



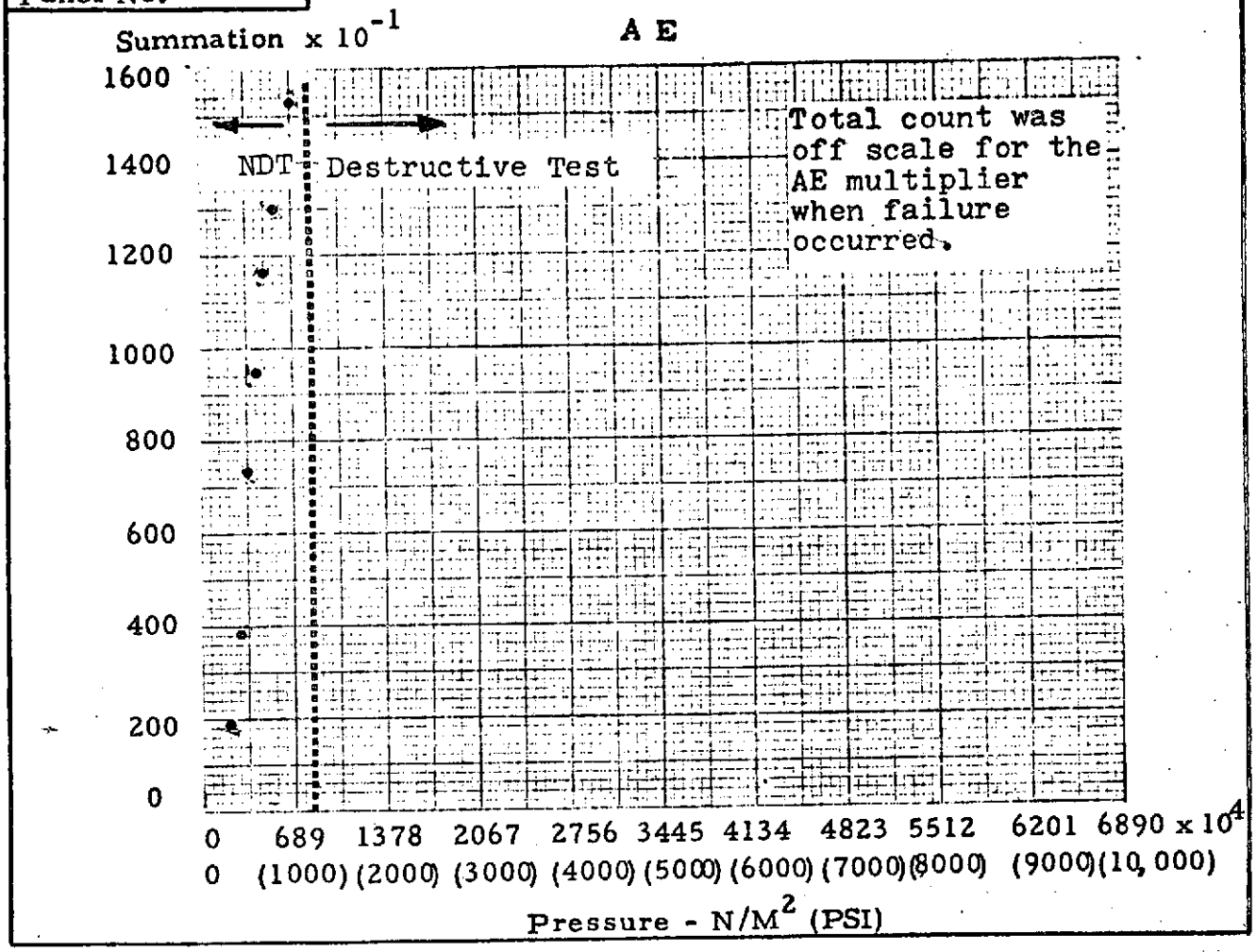
Section showing failure in the planned weak bond. Magnification 50X.

Section of planned full bond in area next to the weak bond. Magnification 50X.

Area of panel failure at Land 3. Note that the thin coverplate failed - not the bond. Magnification 50X.

FIGURE C-31

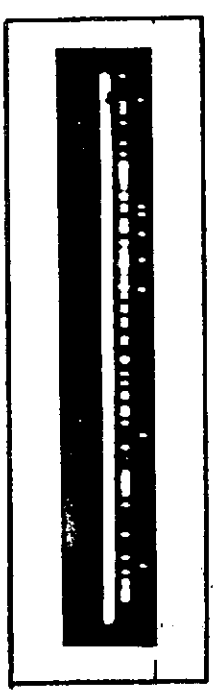
Panel No. C-36N



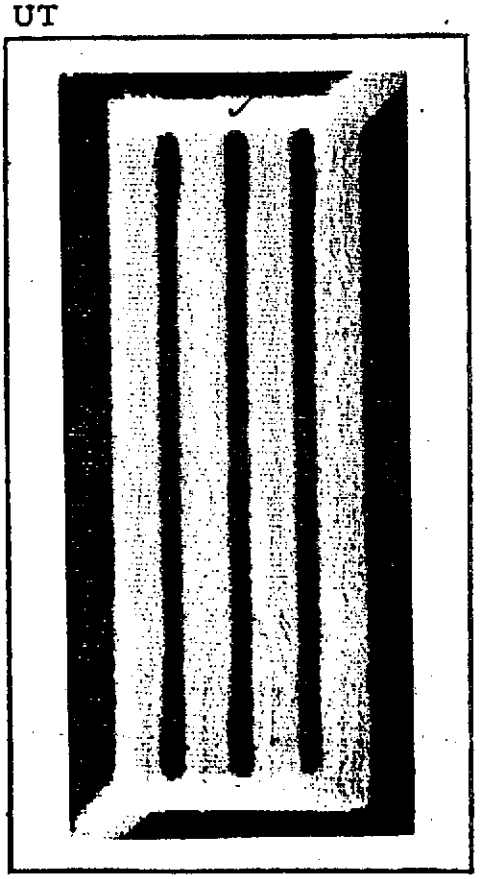
HNDT (Before AE)

Press. 10.4 x 10^5 N/M^2
(150 PSI)

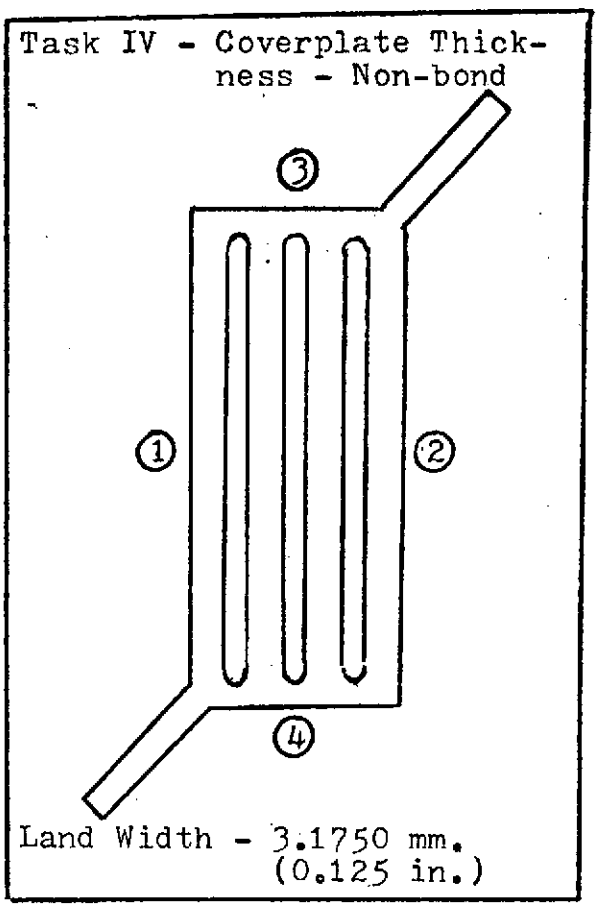
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-37N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.0035 in. (0.0889 mm.)

THICKNESS:	MM.	INCHES
①	6.4186	0.2527
②	6.4643	0.2545
③	6.4745	0.2549
④	6.3983	0.2519

COVERPLATE

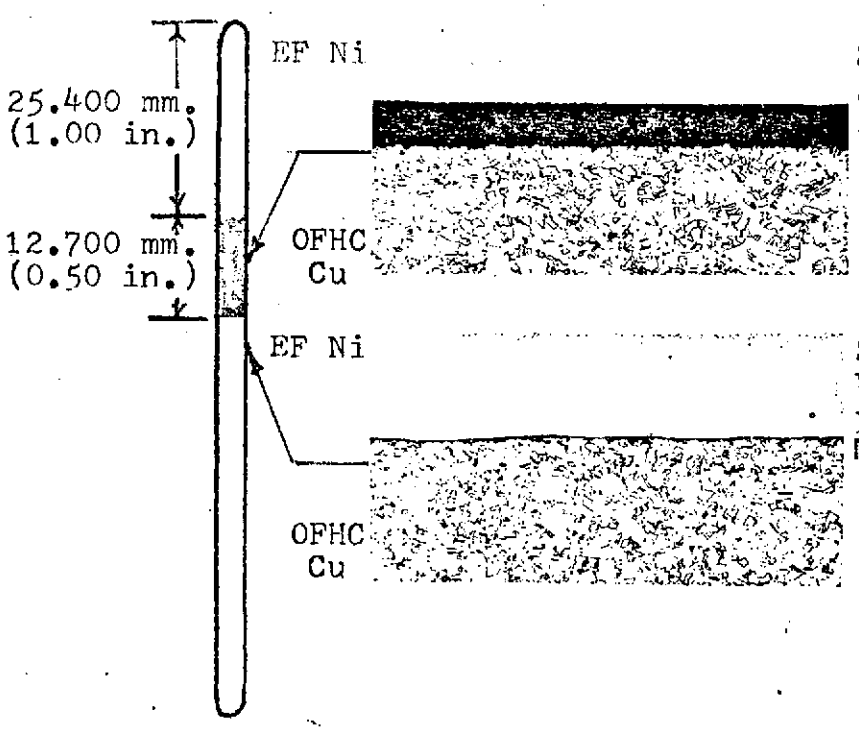
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.7518	0.0296
②	0.6782	0.0267
③	0.6502	0.0256
④	0.7823	0.0308

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 1.86×10^7 N/m^2 (2,700 psi).

CENTER LAND DEFECT METALLOGRAPHIC ANALYSIS:

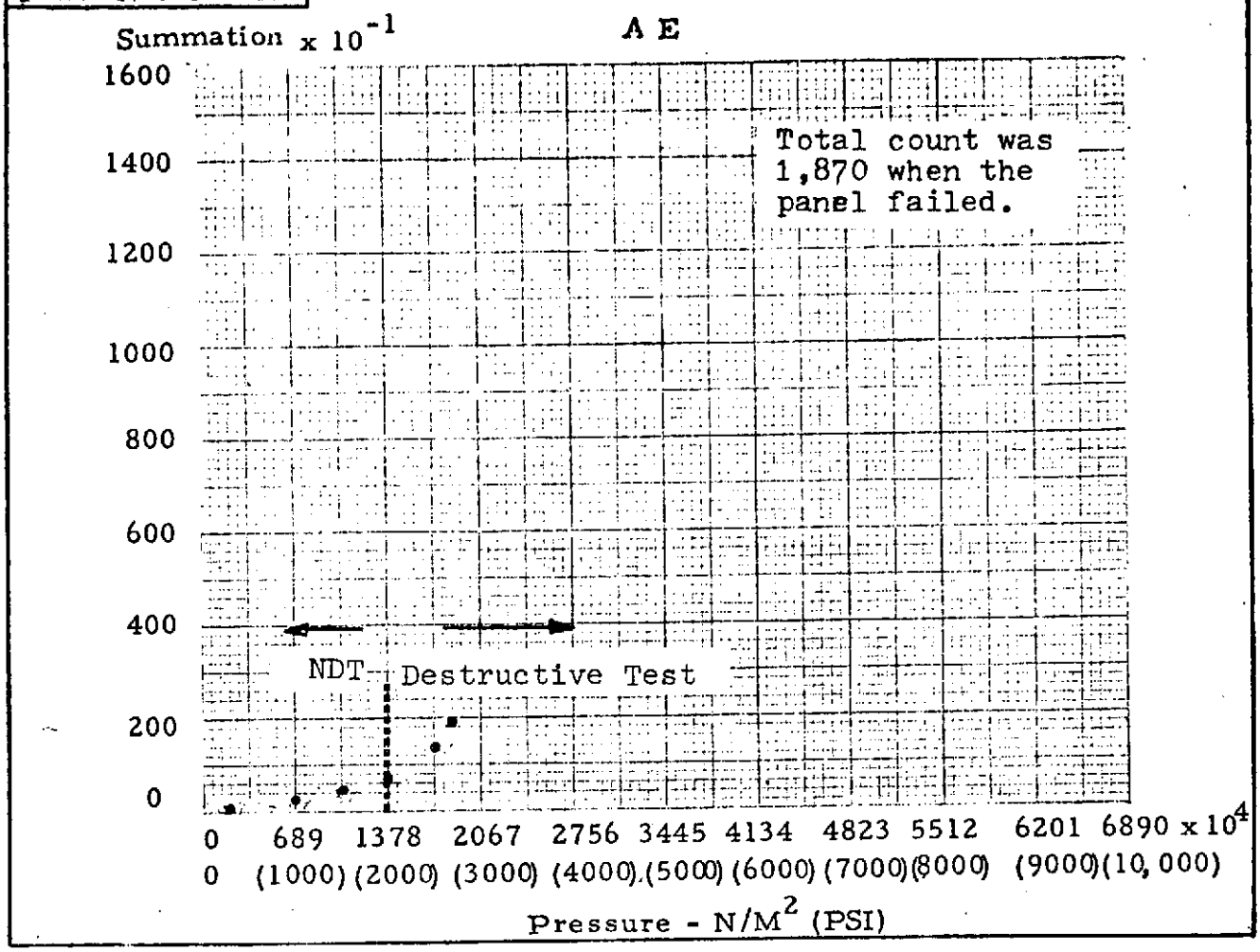


Section showing nonbond separation. Magnification 50X.

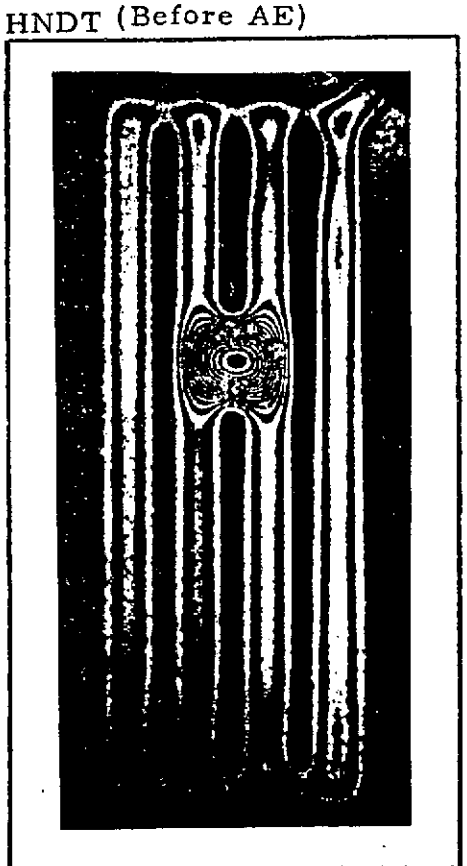
Section showing full bond adjacent to the planned nonbond. Magnification 50X.

FIGURE C-32

Panel No. C-37N

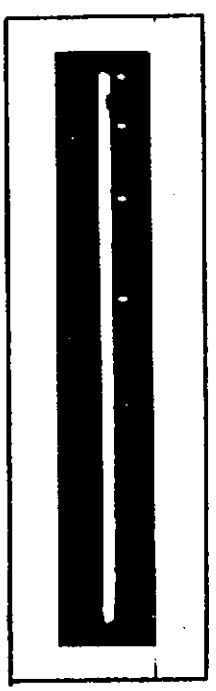


HNDT (Before AE)

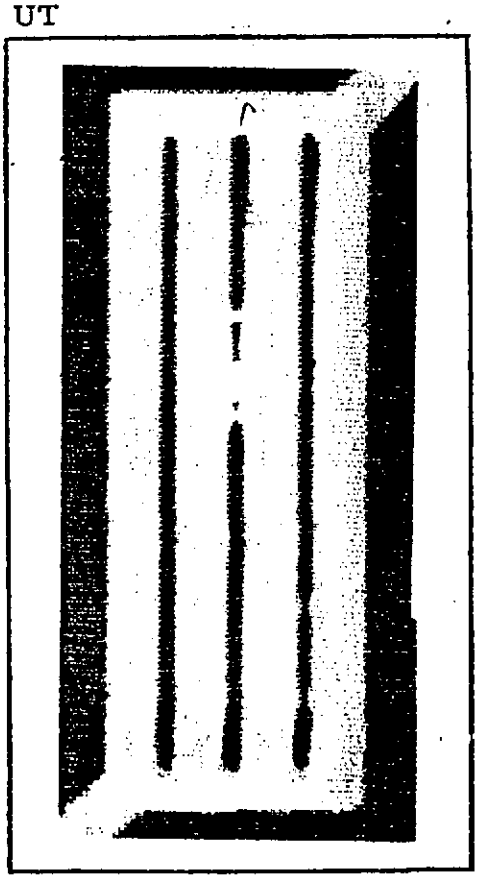


Press. - 3.45 x 10^5 N/M^2
(50 PSI)

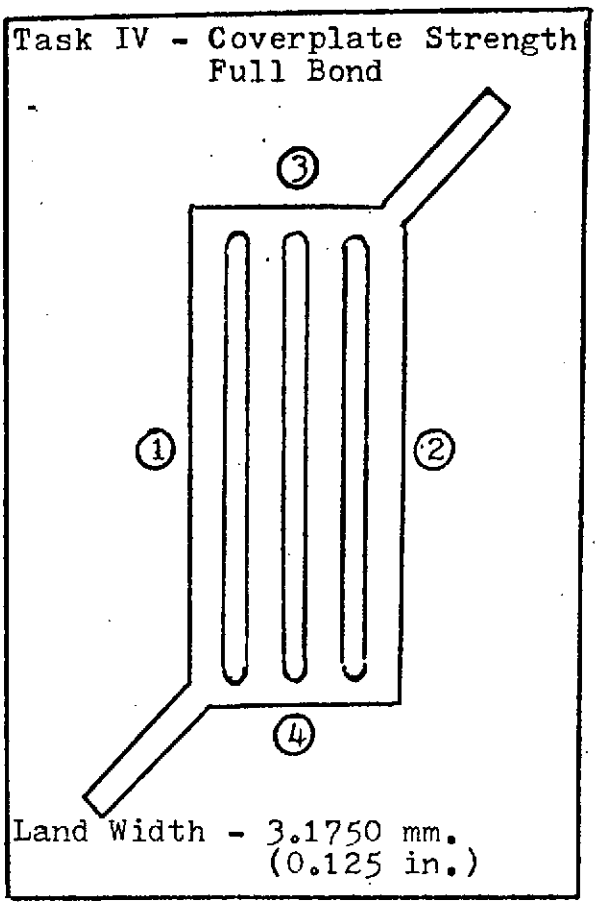
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-06N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.5481	0.2578
②	6.5405	0.2575
③	6.6091	0.2602
④	6.4973	0.2558

COVERPLATE

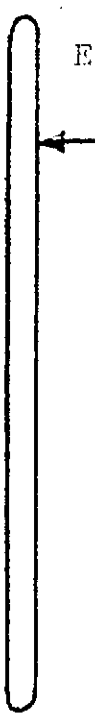
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9754	0.0384
②	0.9754	0.0384
③	0.9296	0.0366
④	1.0439	0.0411

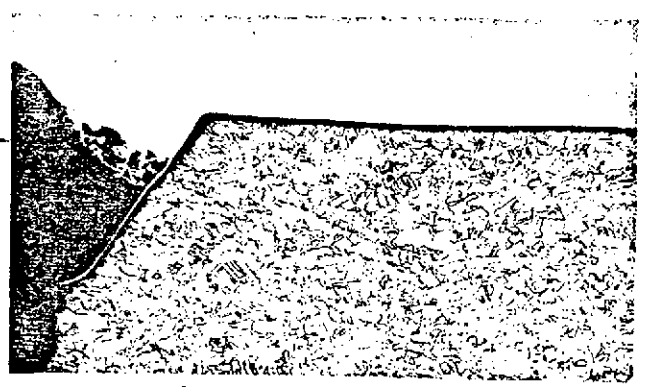
PRESSURE REQUIRED TO FAIL BOND:

Panel did not fail at a pressure of 6.90×10^7 N/m^2 (10,000 psi). Slight coverplate deformation at the channels occurred.

CENTER LAND DEFECT



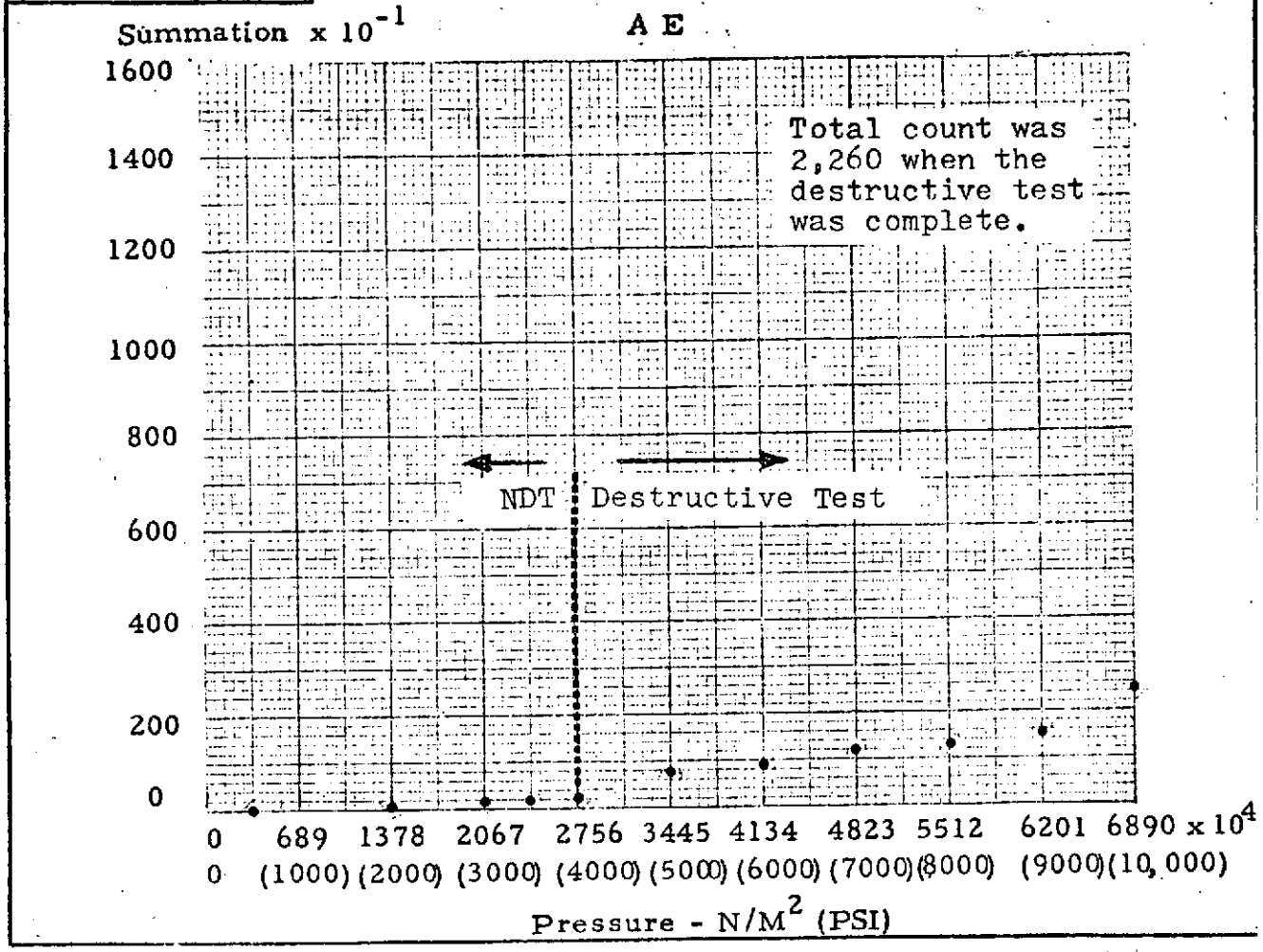
METALLOGRAPHIC ANALYSIS:



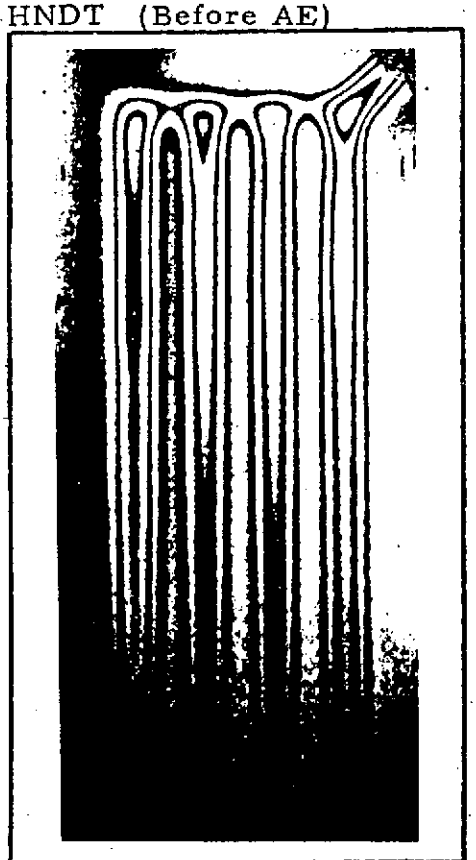
Section showing full bond intact.
Magnification 50X.

FIGURE C-33

Panel No. C-6N

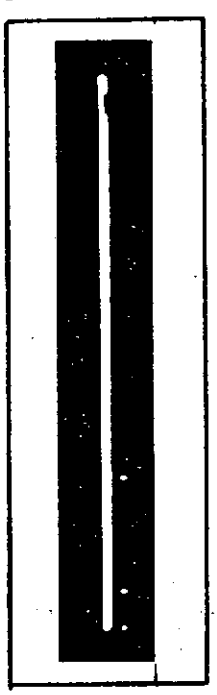


HNDT (Before AE)

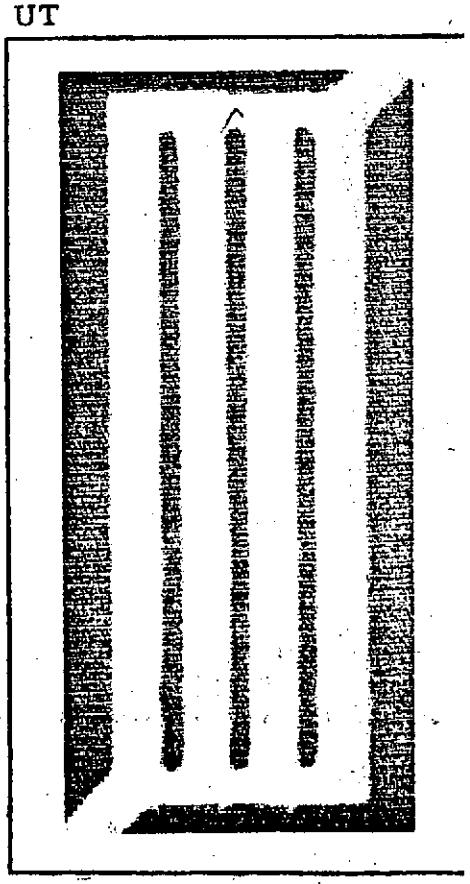


Press. 13.8 x 10^5 N/M^2 (200 PSI)

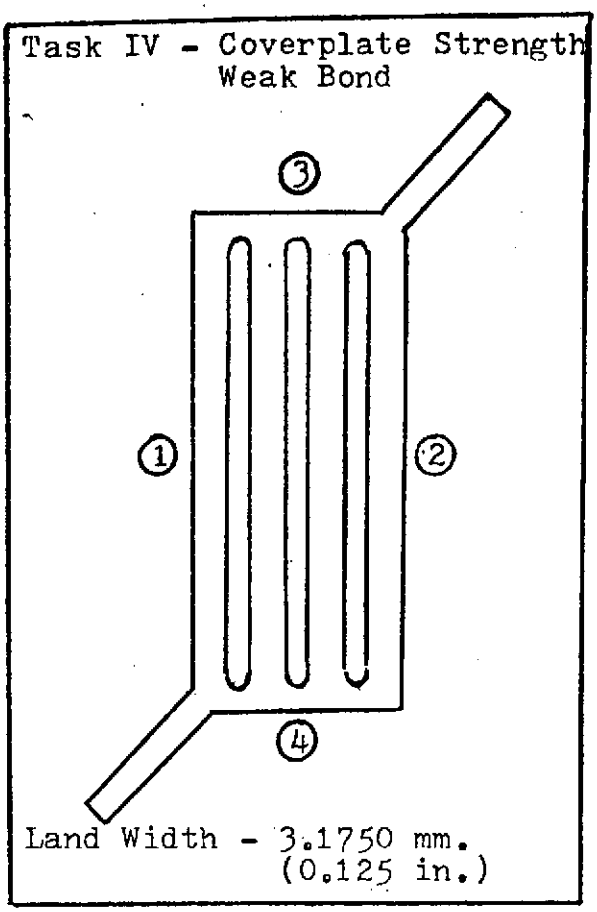
AE FLAW LOCATOR CENTER LAND



UT



ELECTROFORMED PANEL NO. C-38N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.0035 in. (0.0889 mm.)

THICKNESS:	MM.	INCHES
①	6.5532	0.2580
②	6.5938	0.2596
③	6.5303	0.2571
④	6.5964	0.2597

COVERPLATE

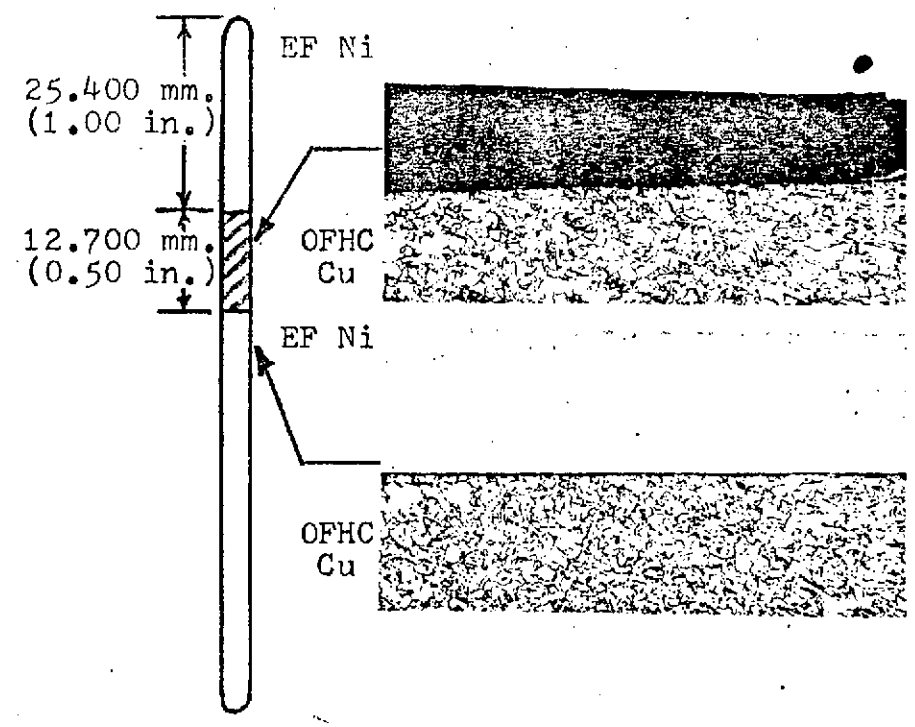
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9449	0.0372
②	0.9347	0.0368
③	0.9855	0.0388
④	0.8915	0.0351

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 3.45×10^7 N/m^2 (5,000 psi).

CENTER LAND DEFECT



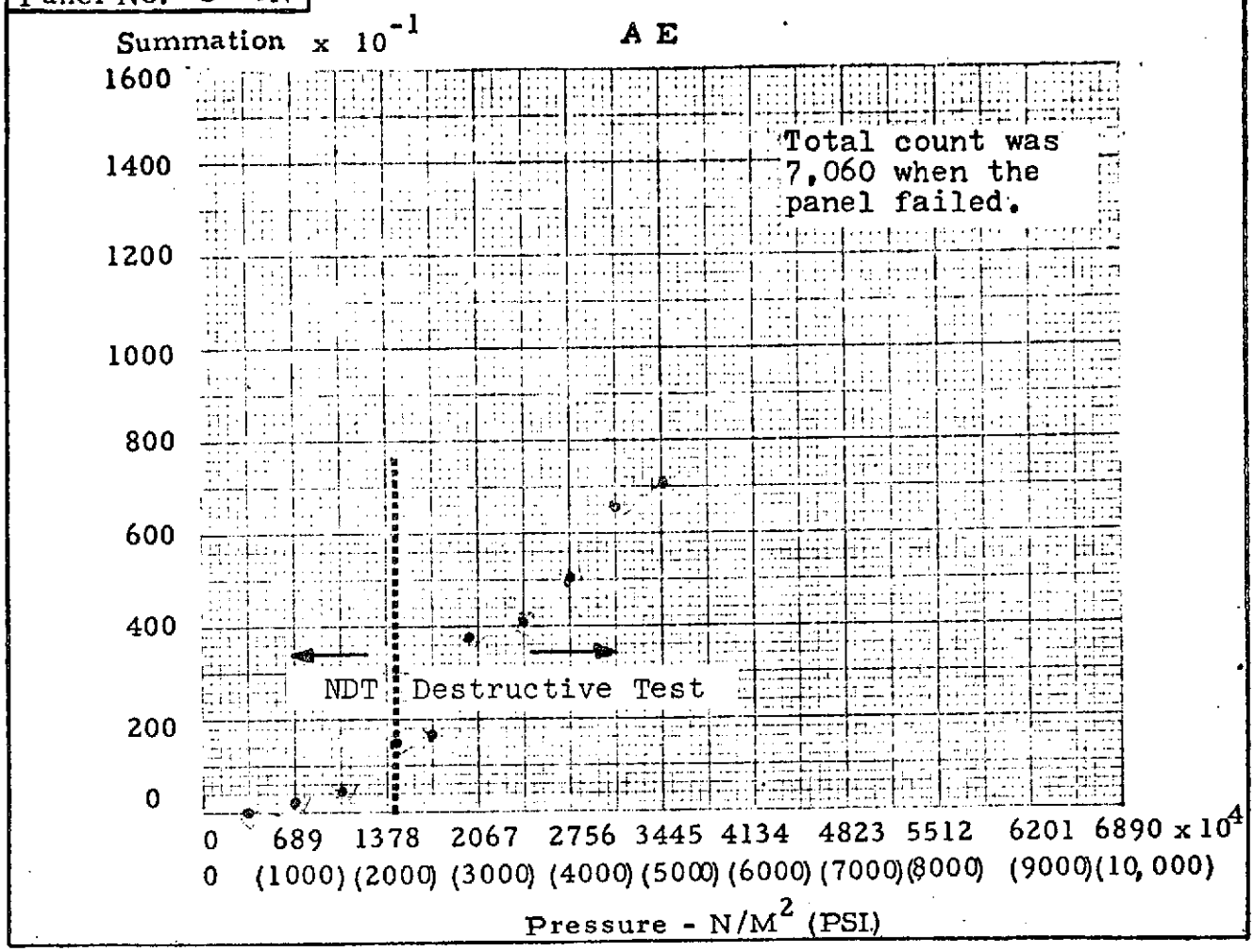
METALLOGRAPHIC ANALYSIS:

Section of planned weak bond showing separation after pressurization to destruction. Magnification 50X.

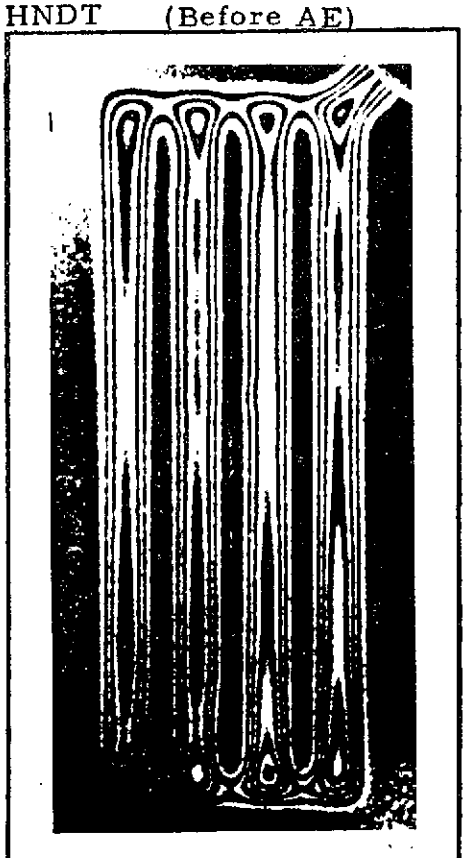
Section showing full bond from region just below the weak bond after destructive test. Magnification 50X.

FIGURE C-34

Panel No. C-38N



HNDT (Before AE)

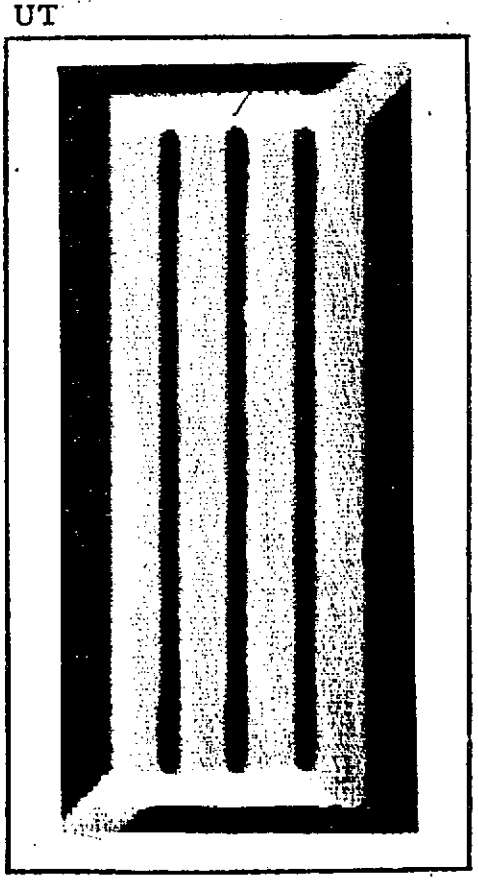


Press. 13.8 x 10^5 N/M^2
(200 PSI)

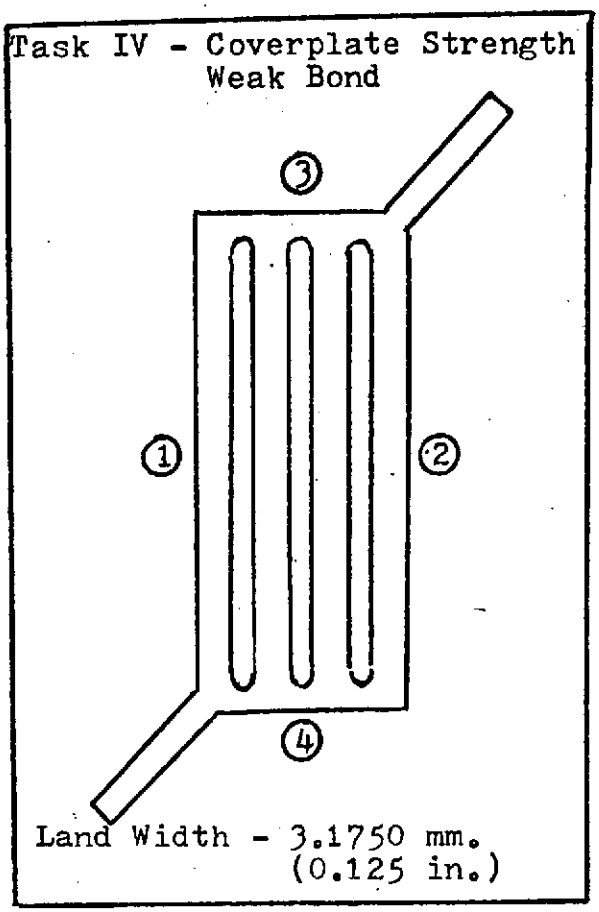
AE
FLAW LOCATOR
CENTER LAND

After NDE and
Destructive Test

UT



ELECTROFORMED PANEL NO. C-39N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION:
0.006 in. (0.1524 mm.)

THICKNESS:	MM.	INCHES
①	6.5888	0.2594
②	6.5557	0.2581
③	6.6599	0.2622
④	6.5126	0.2564

COVERPLATE

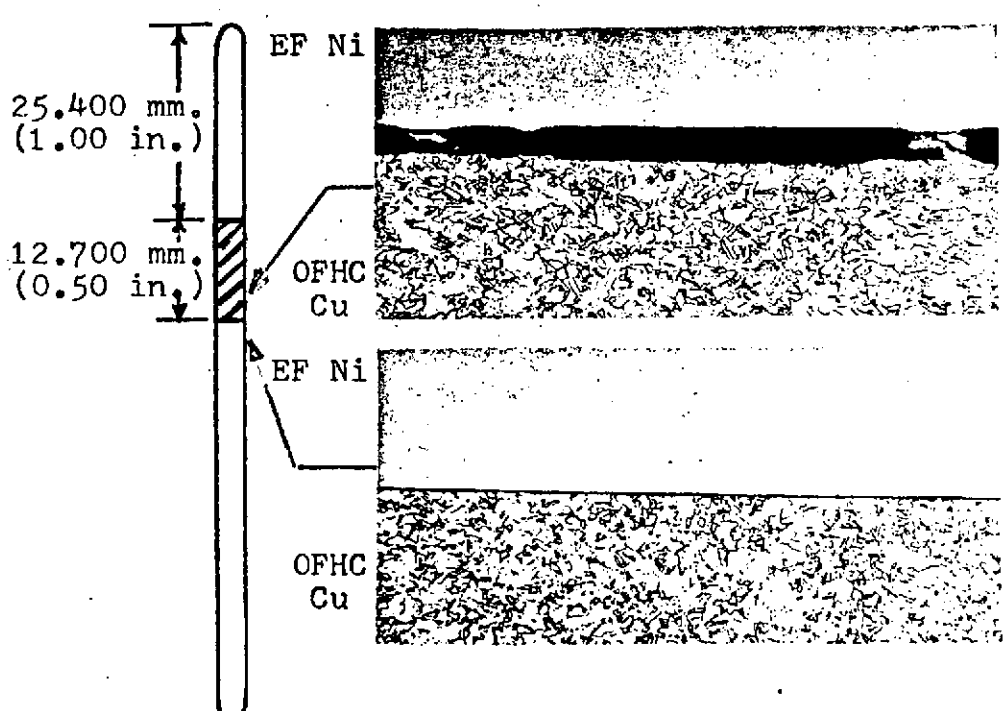
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9246	0.0364
②	0.9195	0.0362
③	0.8484	0.0334
④	0.9754	0.0384

PRESSURE REQUIRED TO FAIL BOND:
Bond failed at a pressure of 5.52×10^7 N/m^2 (8,000 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

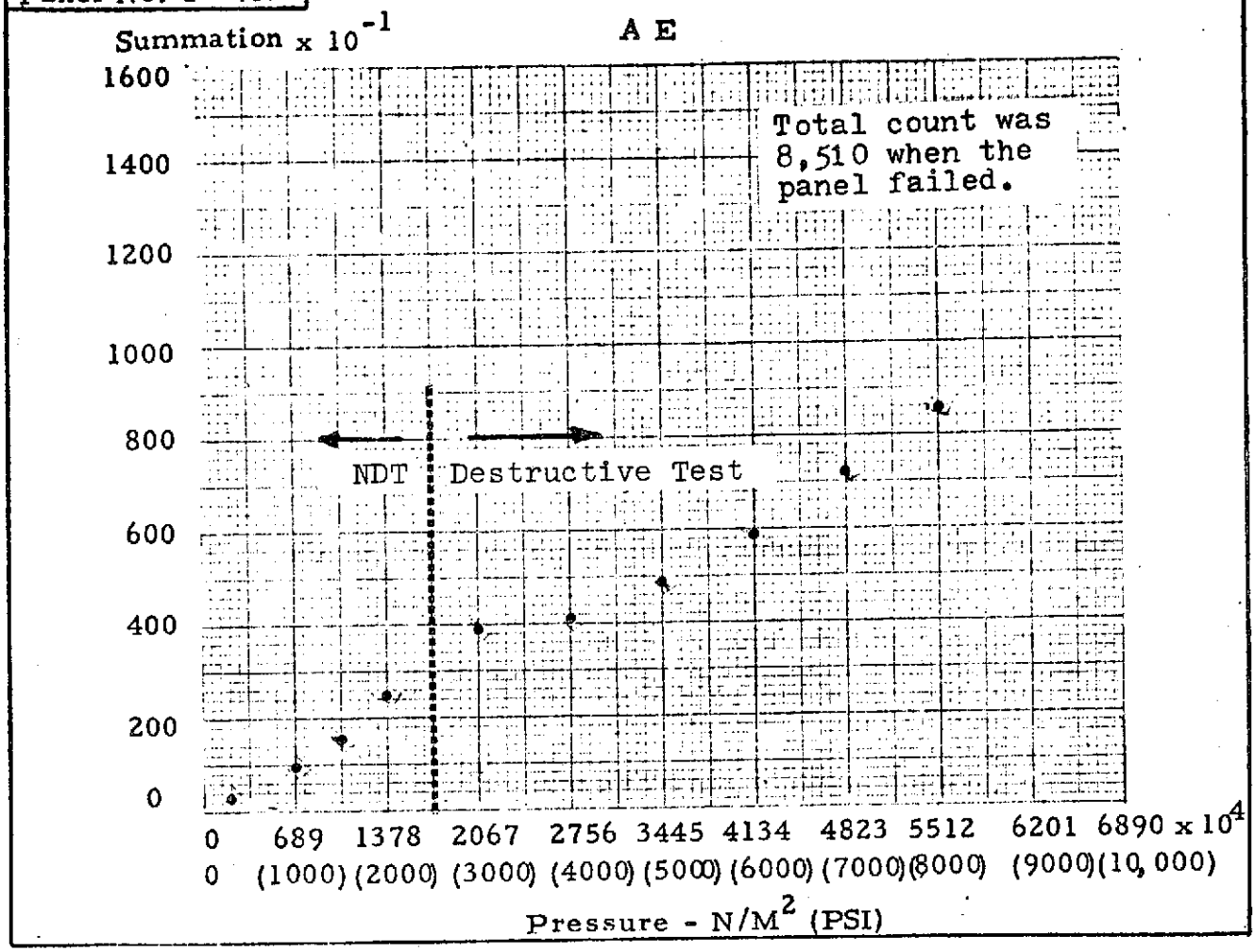


Planned weak bond section. Disturbance of OFHC copper indicates a stronger bond than planned. Magnification 50X

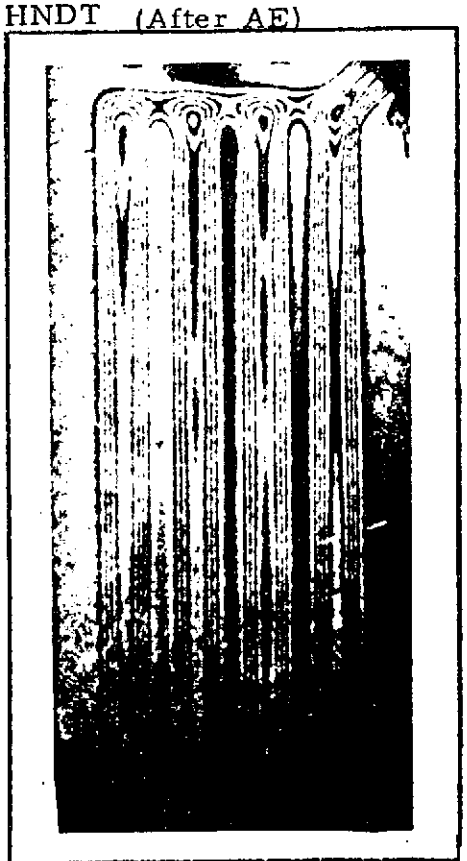
Section of full bond adjacent to planned weak bond. Magnification 50X.

FIGURE C-35

Panel No. C-39N

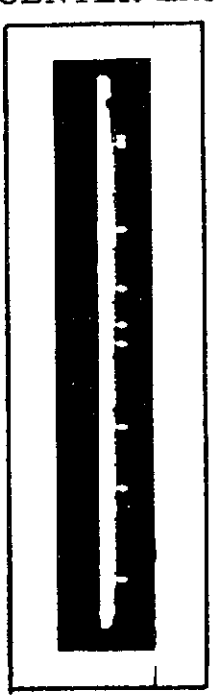


HNDT (After AE)

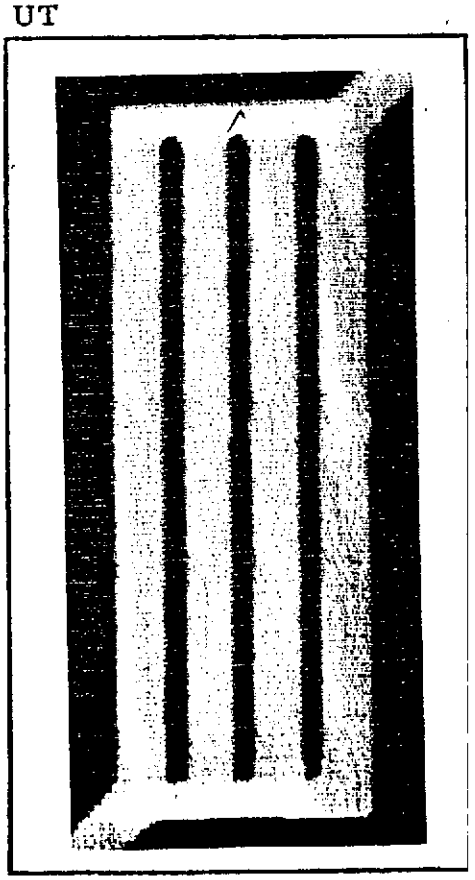


Press. - 20.7 x 10^5 N/M^2
(300 PSI)

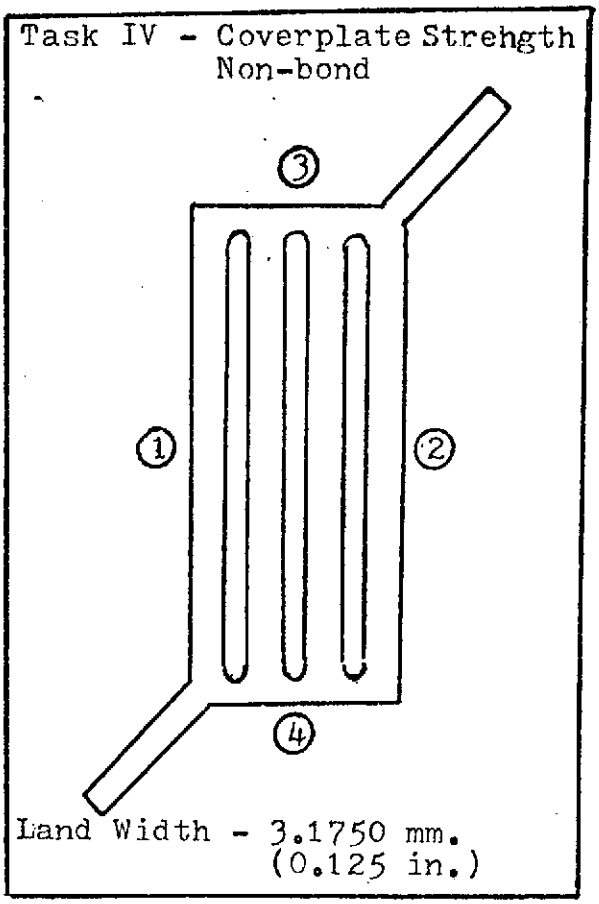
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-03N



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION:
0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.5964	0.2597
②	6.6472	0.2617
③	6.6269	0.2609
④	6.5811	0.2591

COVERPLATE

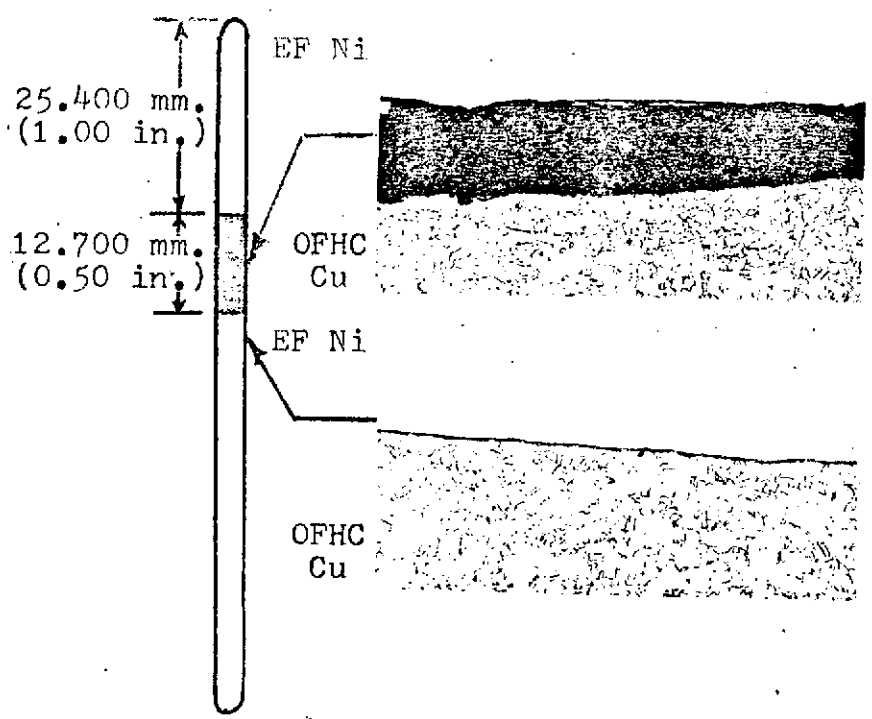
MATERIAL: Electroformed Nickel

THICKNESS:	MM.	INCHES
①	0.9169	0.0361
②	0.9169	0.0361
③	0.9347	0.0368
④	0.9347	0.0368

PRESSURE REQUIRED TO FAIL BOND:
Panel failed at a pressure of 2.35×10^7 N/m^2 (3,400 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

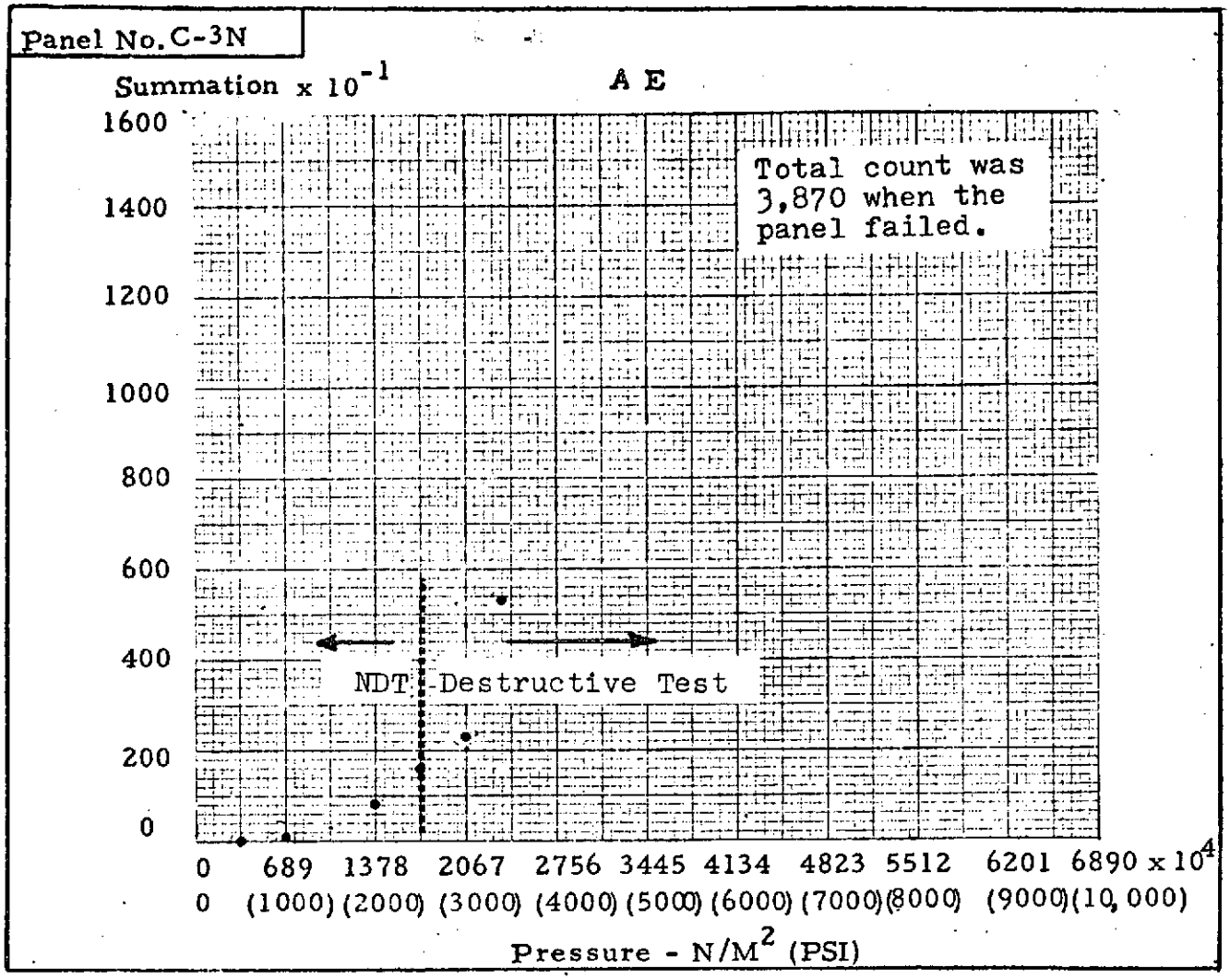


Section showing the planned nonbond separation after destructive test. Magnification 50X. Very slight metal disturbance indicates some "tack" bonding was present.

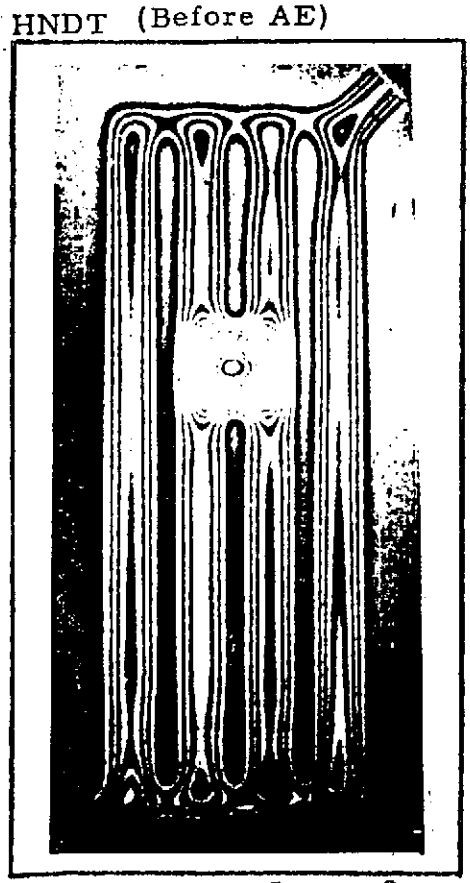
View of full bond area adjacent to the planned nonbond. Magnification 50X.

FIGURE C-36

Panel No. C-3N

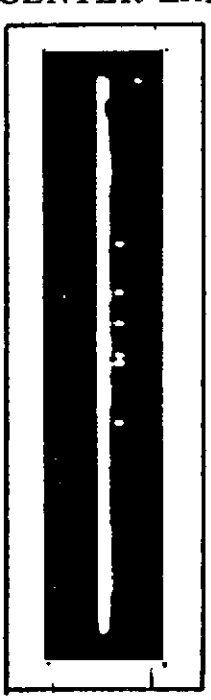


HNDT (Before AE)

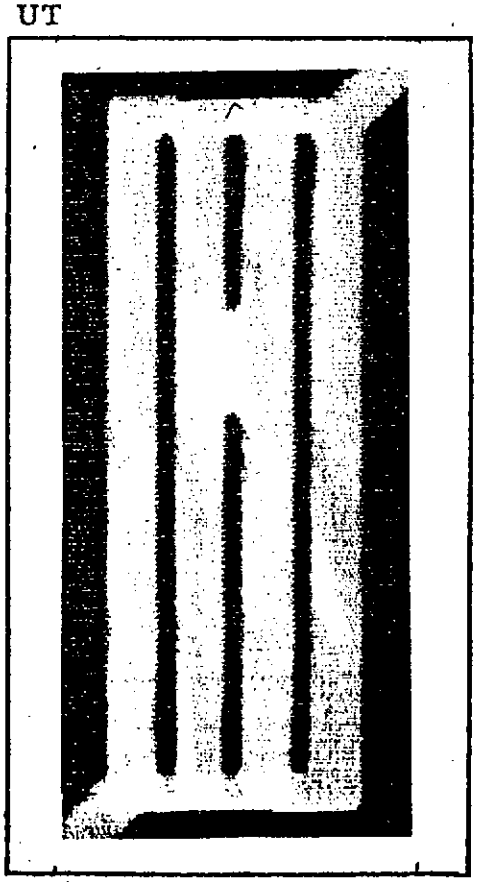


Press. 6.9×10^5 N/M^2
(100 PSI)

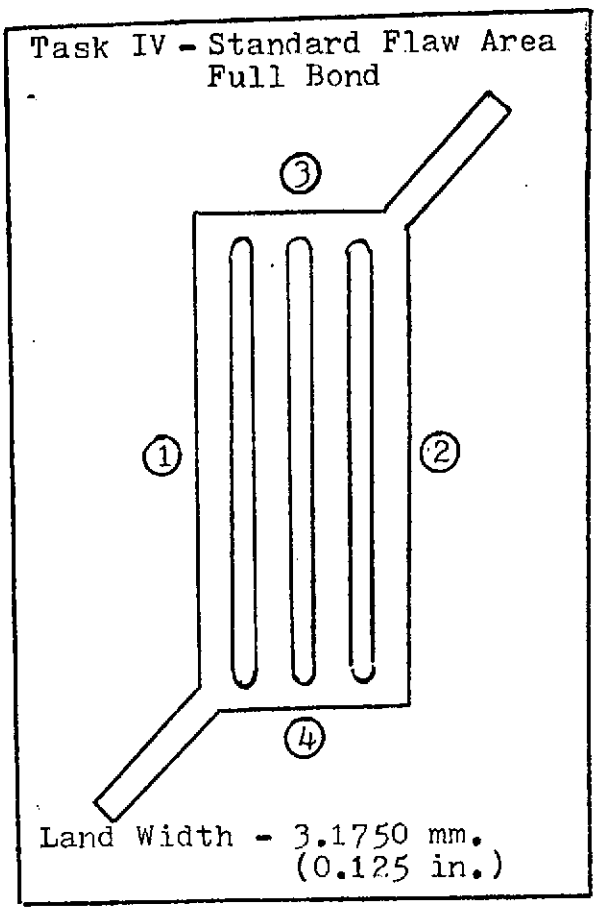
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-01C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.4922	0.2556
②	6.4821	0.2552
③	6.5075	0.2562
④	6.4897	0.2555

COVERPLATE

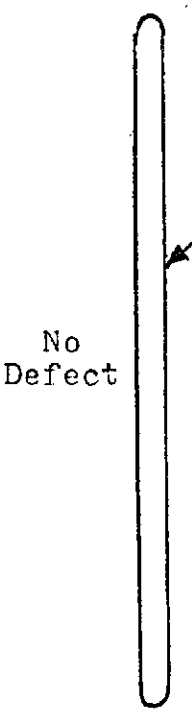
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2344	0.0486
②	1.2700	0.0500
③	1.2370	0.0487
④	1.2725	0.0501

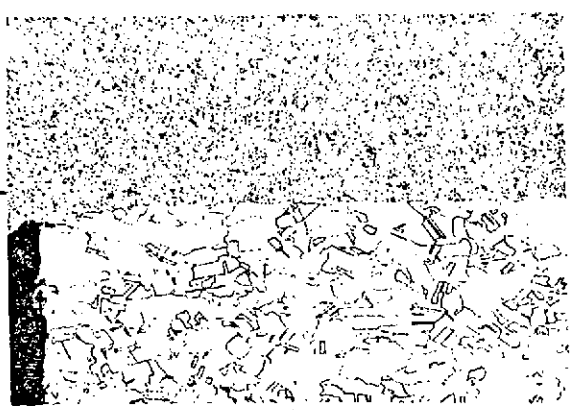
PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 5.52×10^7 N/m^2 (8,000 psi). Failure was by manifold buckling.

CENTER LAND DEFECT



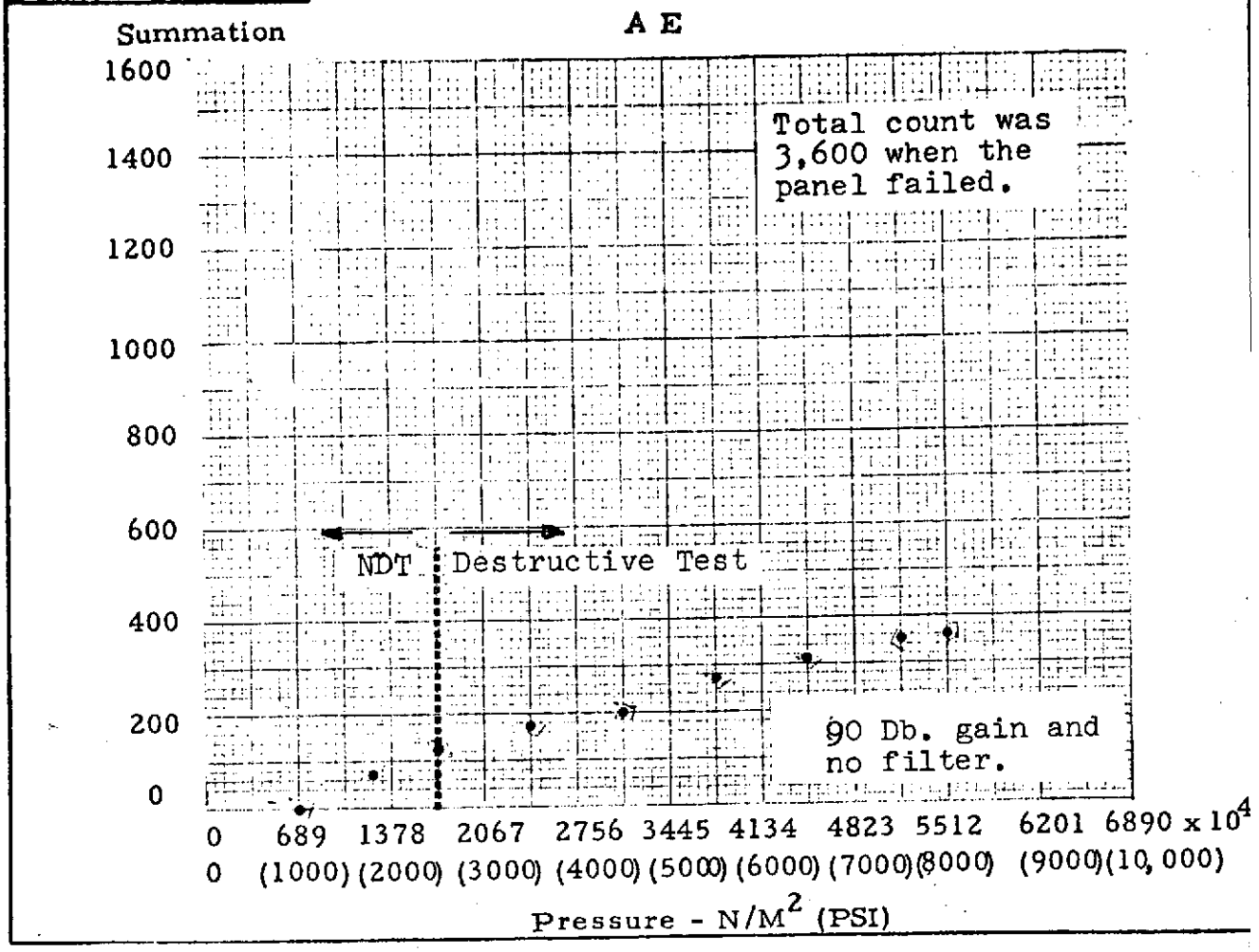
METALLOGRAPHIC ANALYSIS:



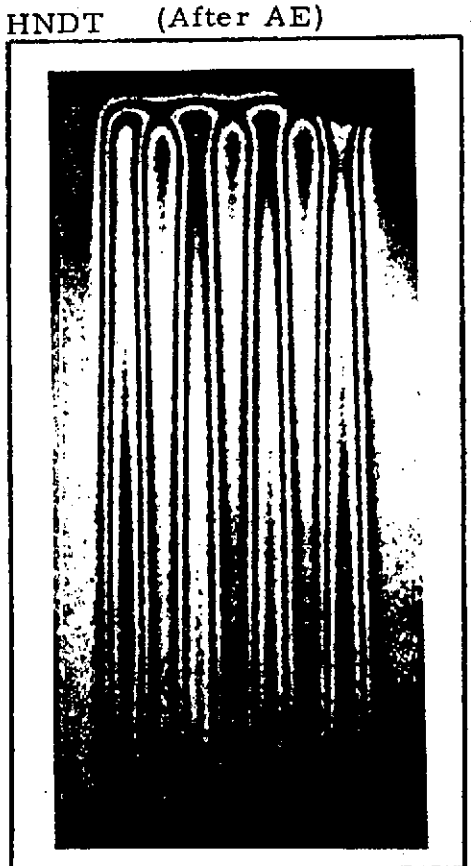
Section of the full bond in Land 2. Note that failure has just begun to occur at the edge of the land. Magnification 100X.

FIGURE C-37

Panel No. C-1C

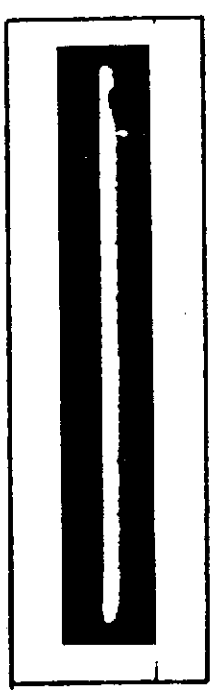


HNDT (After AE)

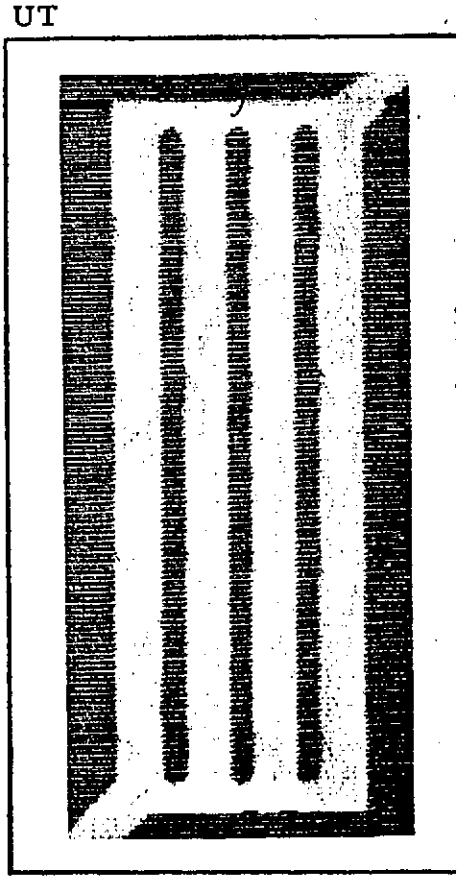


Press. 20.7×10^5 N/M^2 (300 PSI)

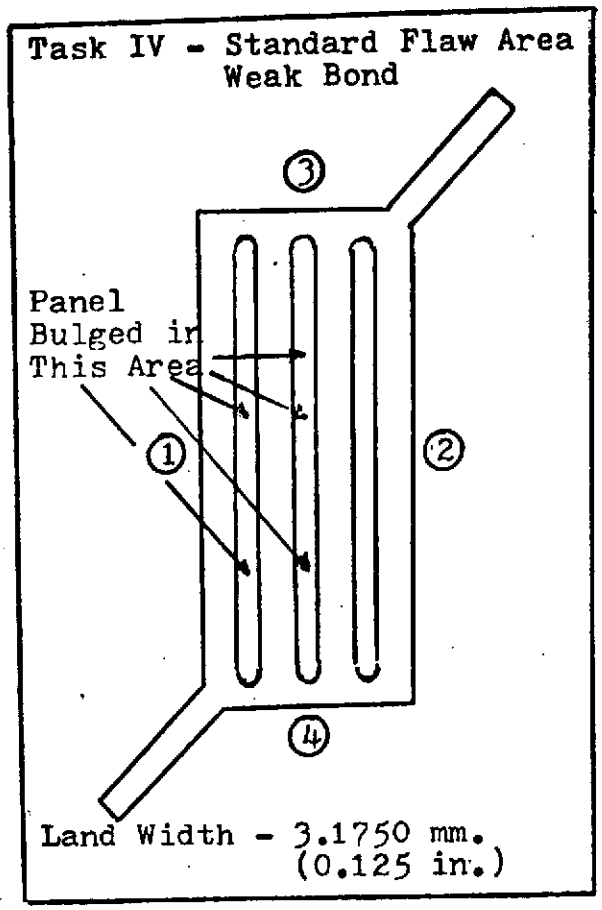
AE FLAW LOCATOR CENTER LAND



UT



ELECTROFORMED PANEL NO. C-16C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION:
0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.6345	0.2612
②	6.6751	0.2628
③	6.6929	0.2635
④	6.6294	0.2610

COVERPLATE

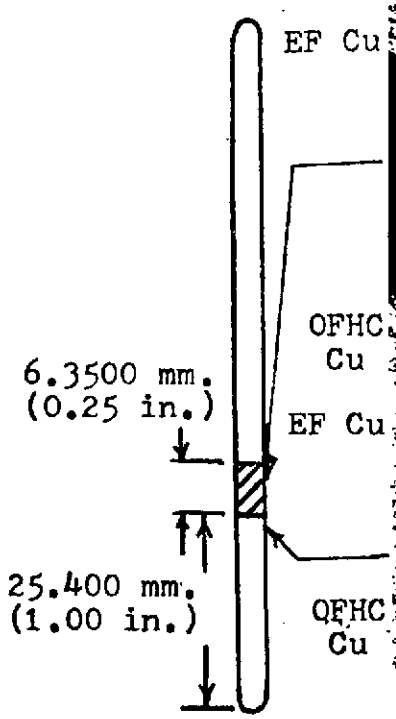
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2598	0.0496
②	1.2700	0.0500
③	1.2675	0.0499
④	1.2624	0.0497

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 3.52×10^7 N/m^2 (5,100 psi).

CENTER LAND DEFECT



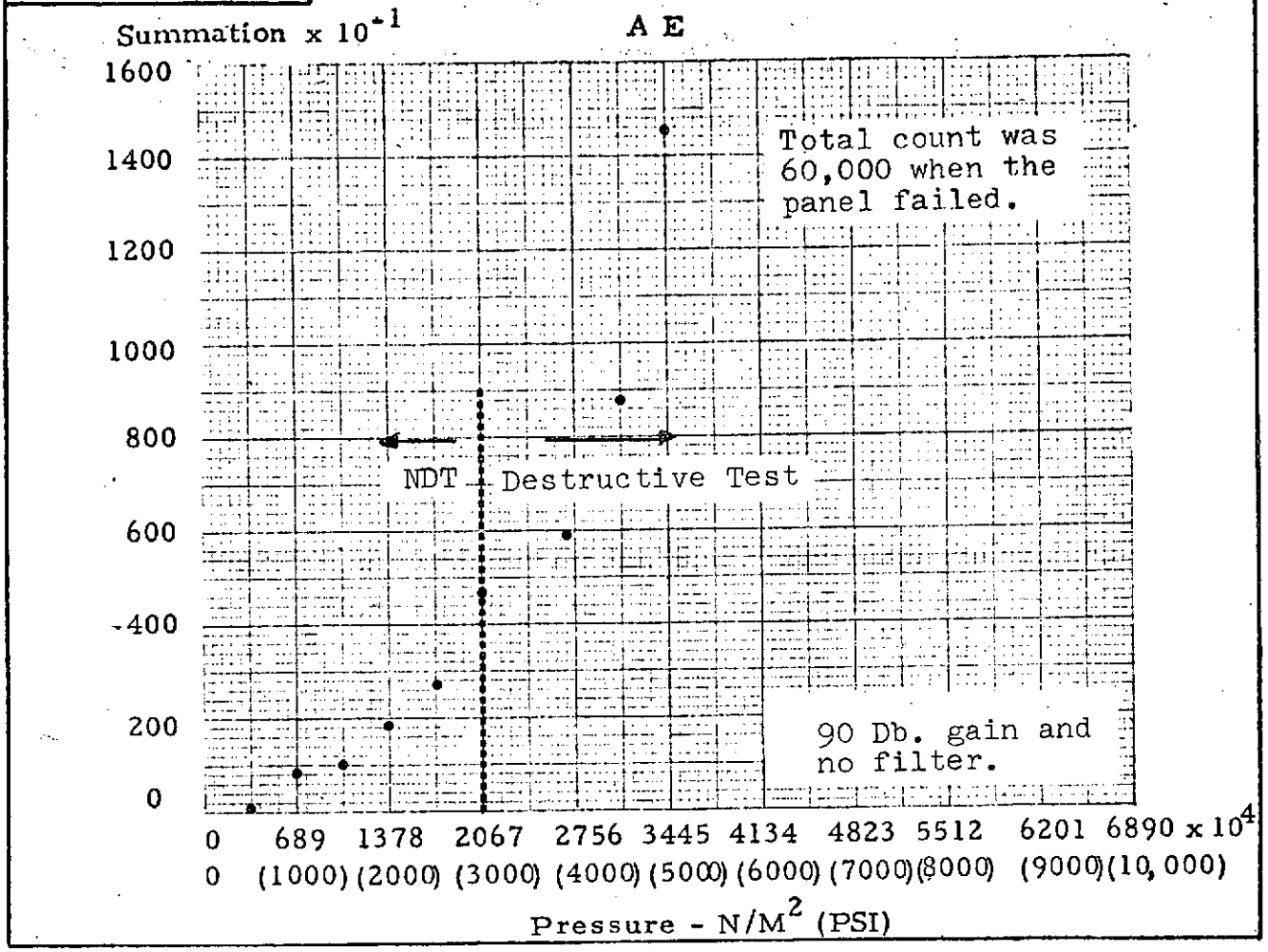
METALLOGRAPHIC ANALYSIS:

Planned weak bond failure. Note the failure as occurring in the EF Cu. Magnification 50X.

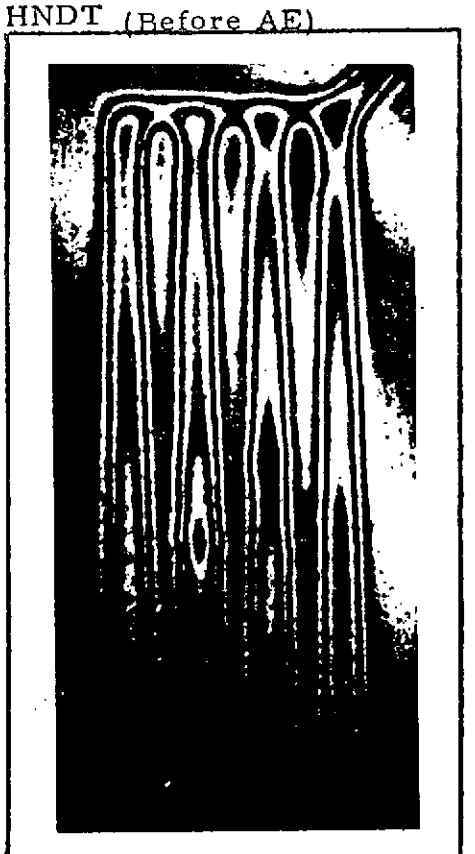
Area of full bond adjacent to the planned weak bond. Magnification 50X.

FIGURE C-38

Panel No.C-16C

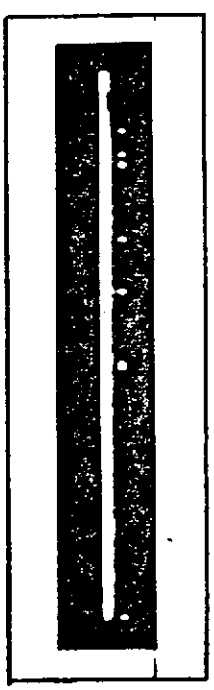


HNDT (Before AE)

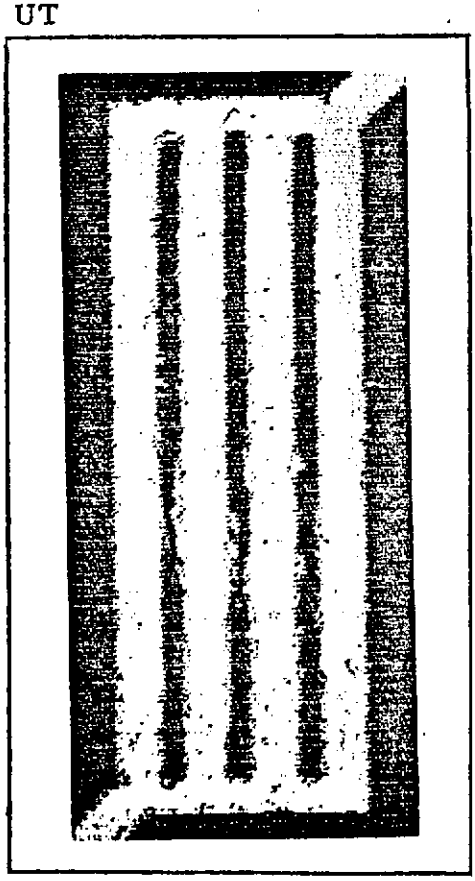


Press. 13.8 x 10^5 N/M^2
(200 PSI)

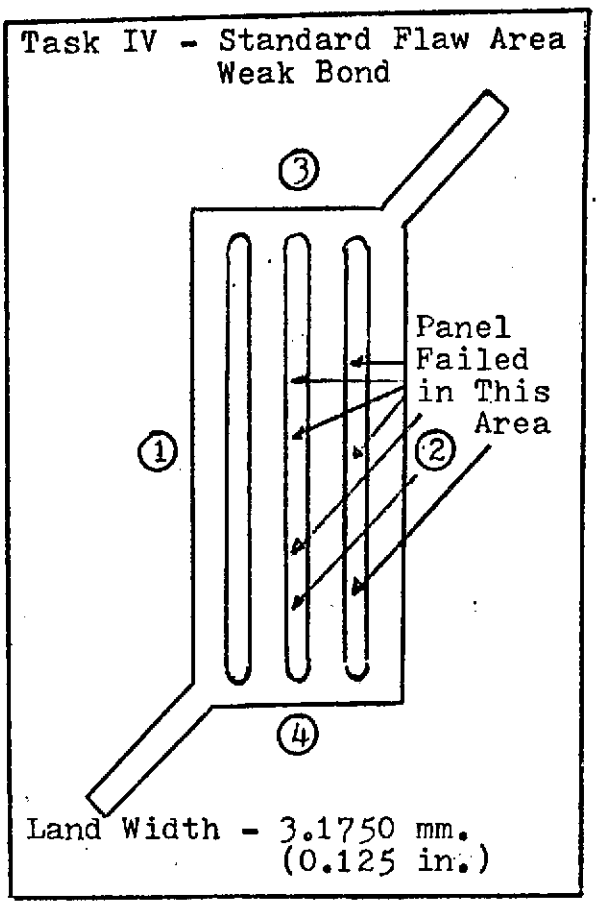
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-17C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.005 in. (0.1270 mm.)

THICKNESS:	MM.	INCHES
①	6.4262	0.2530
②	6.4110	0.2524
③	6.3652	0.2506
④	6.4567	0.2542

COVERPLATE

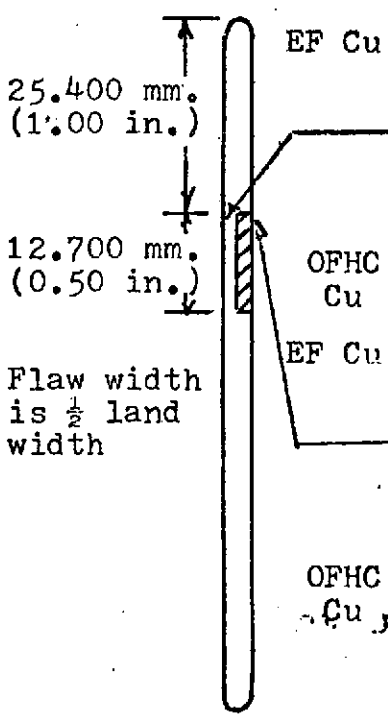
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2370	0.0487
②	1.2954	0.0510
③	1.2979	0.0511
④	1.1862	0.0467

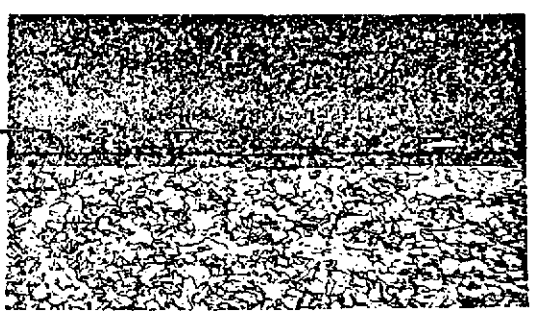
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 2.62×10^7 N/m^2 (3,800 psi).

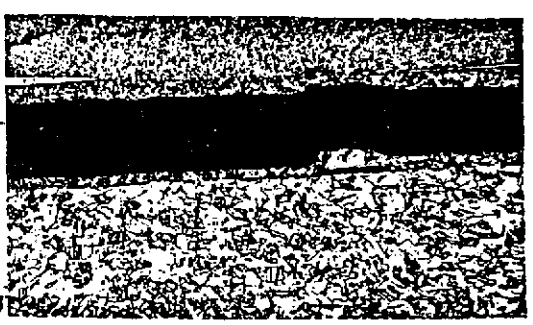
CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



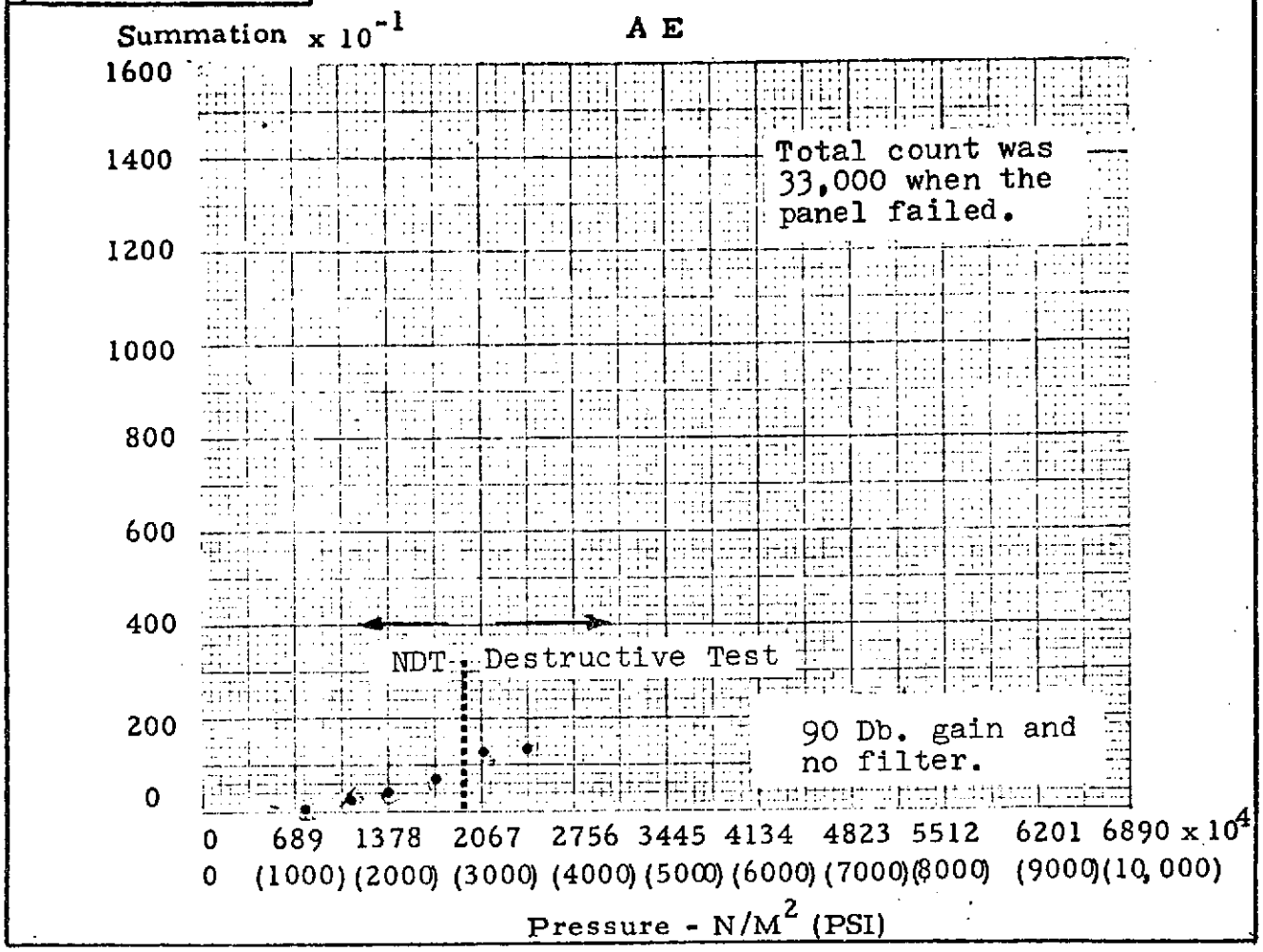
Section of planned full bond running parallel to the planned weak bond. Magnification 50X.



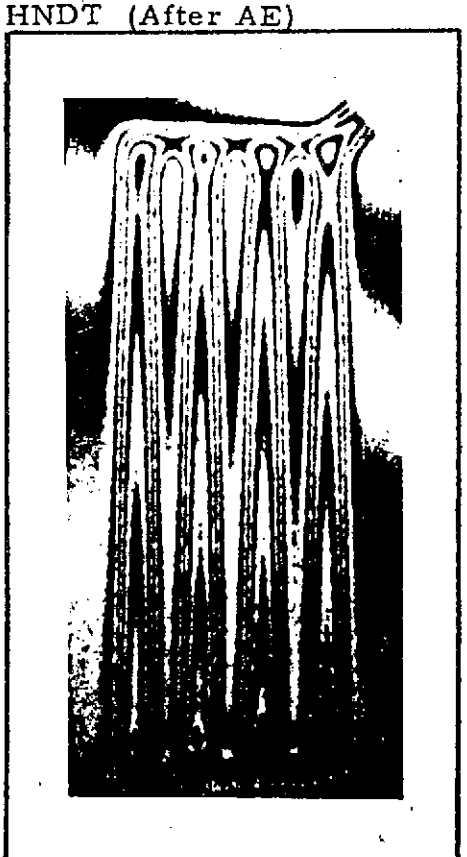
Section showing failure occurring in the planned weak bond area. Magnification 50X.

FIGURE C-39

Panel No. C-17C

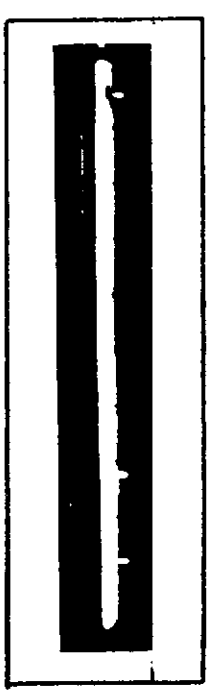


HNDT (After AE)

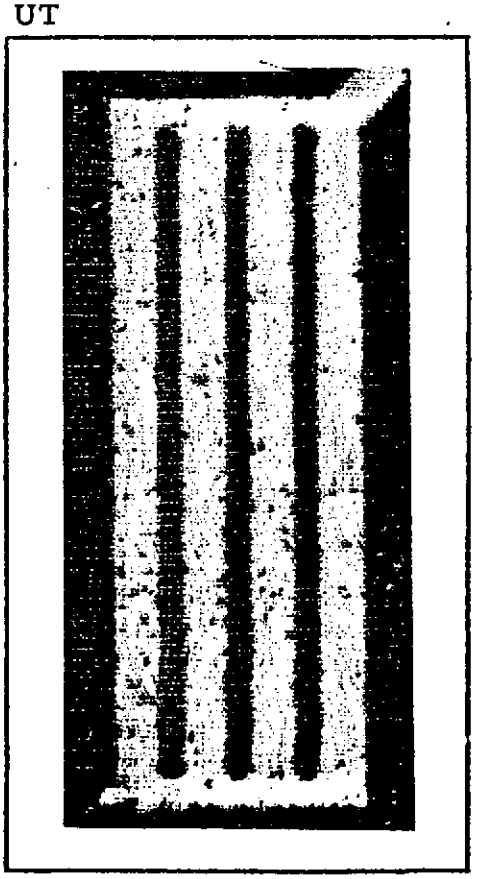


Press. 20.7 x 10^5 N/M^2
(300 PSI)

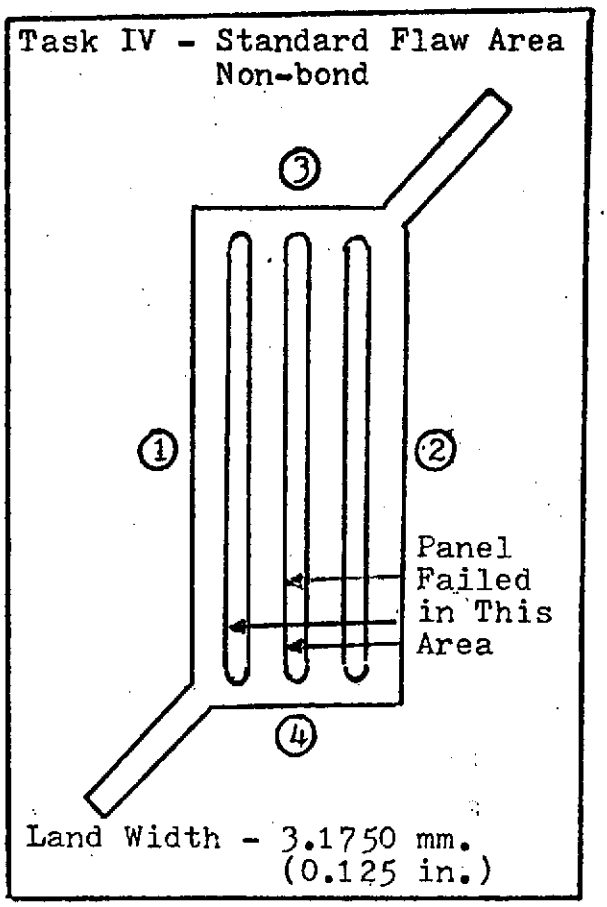
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-18C "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.3830	0.2513
②	6.3500	0.2500
③	6.3754	0.2510
④	6.4135	0.2525

COVERPLATE

MATERIAL: Electroformed Copper

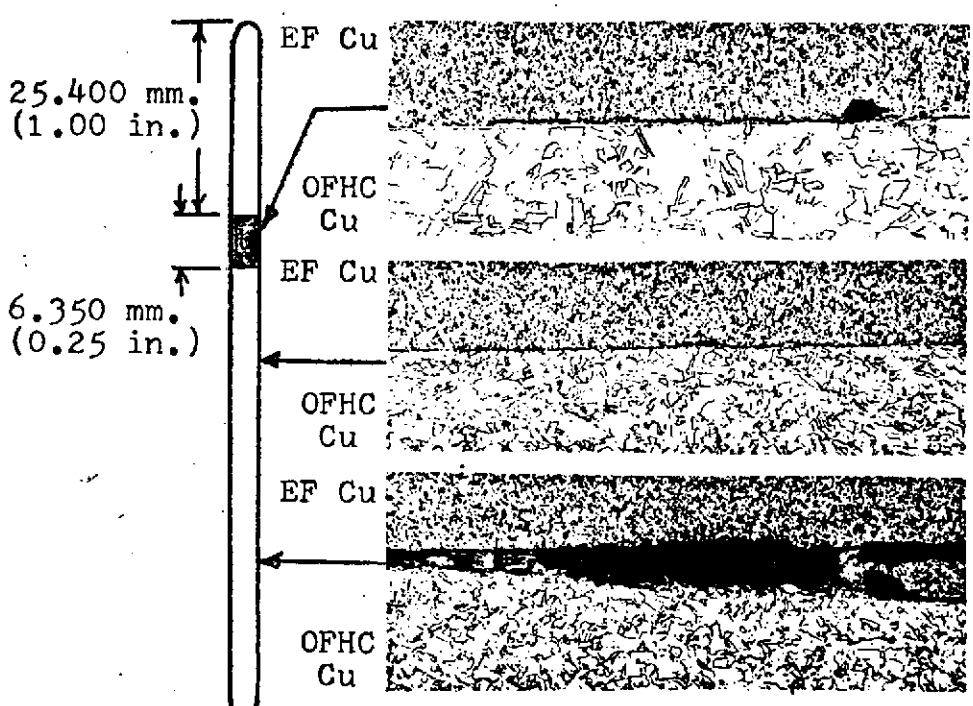
THICKNESS:	MM.	INCHES
①	1.3056	0.0514
②	1.2751	0.0502
③	1.3157	0.0518
④	1.2675	0.0499

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 1.31×10^7 N/m^2 (1,900 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:



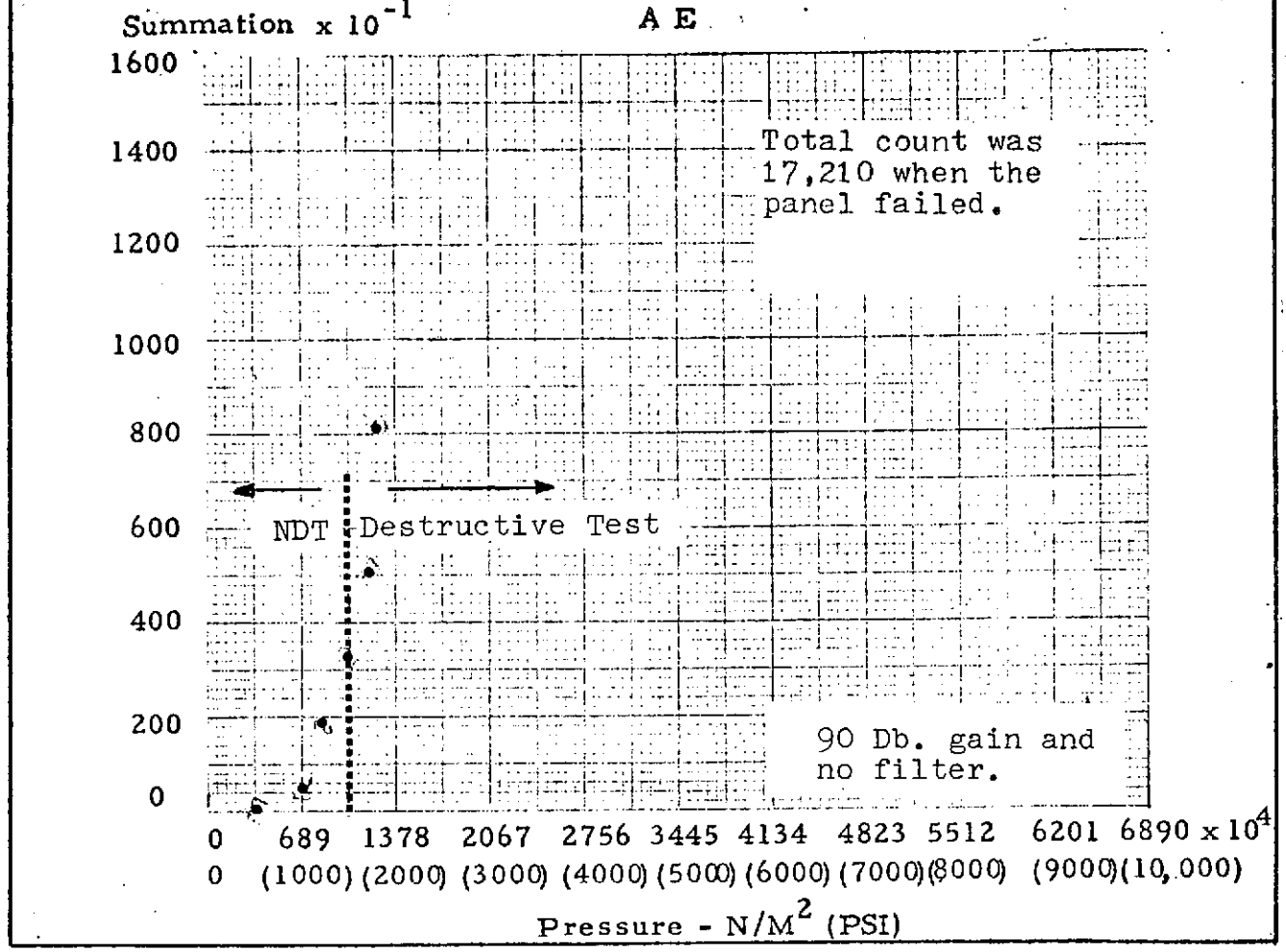
Nonbond flaw area showing slight disturbance but no failure. Magnification 100X.

Planned full bond with no evidence of failure. Magnification 50X.

Planned full bond area which failed prematurely. Magnification 50X.

FIGURE C-40

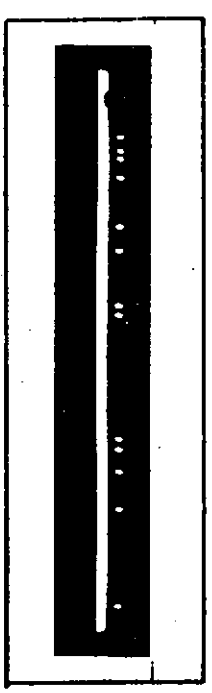
Panel No. C-18C"A"



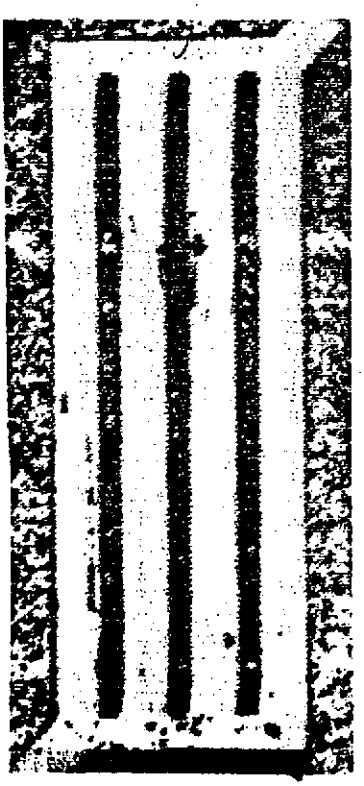
HNDT

No hologram was made due to unexpected bulge from low pressure A E test

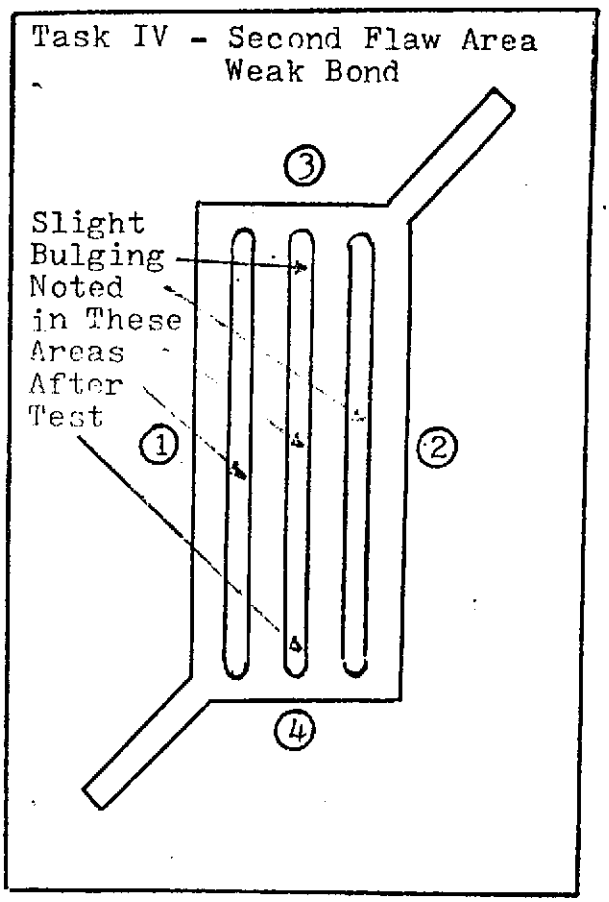
AE FLAW LOCATOR CENTER LAND



UT



ELECTROFORMED PANEL NO. C-19C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.004 in. (0.1016 mm.)

THICKNESS:	MM.	INCHES
①	6.5532	0.2580
②	6.5507	0.2579
③	6.5913	0.2595
④	6.5303	0.2571

COVERPLATE

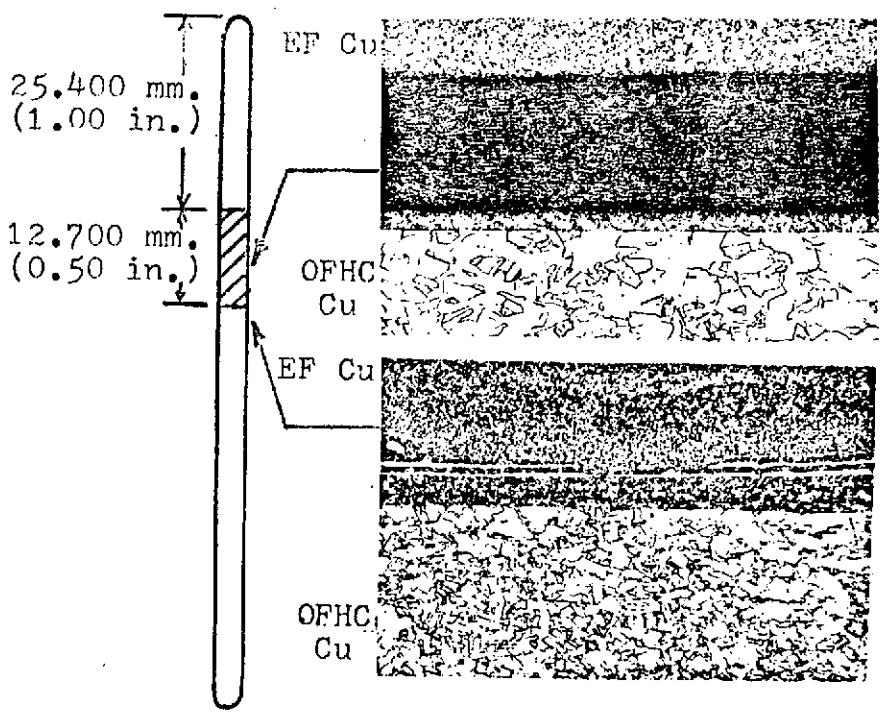
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2548	0.0494
②	1.2319	0.0485
③	1.2065	0.0475
④	1.2598	0.0496

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 1.24×10^7 N/m^2 (1,800 psi).

CENTER LAND DEFECT



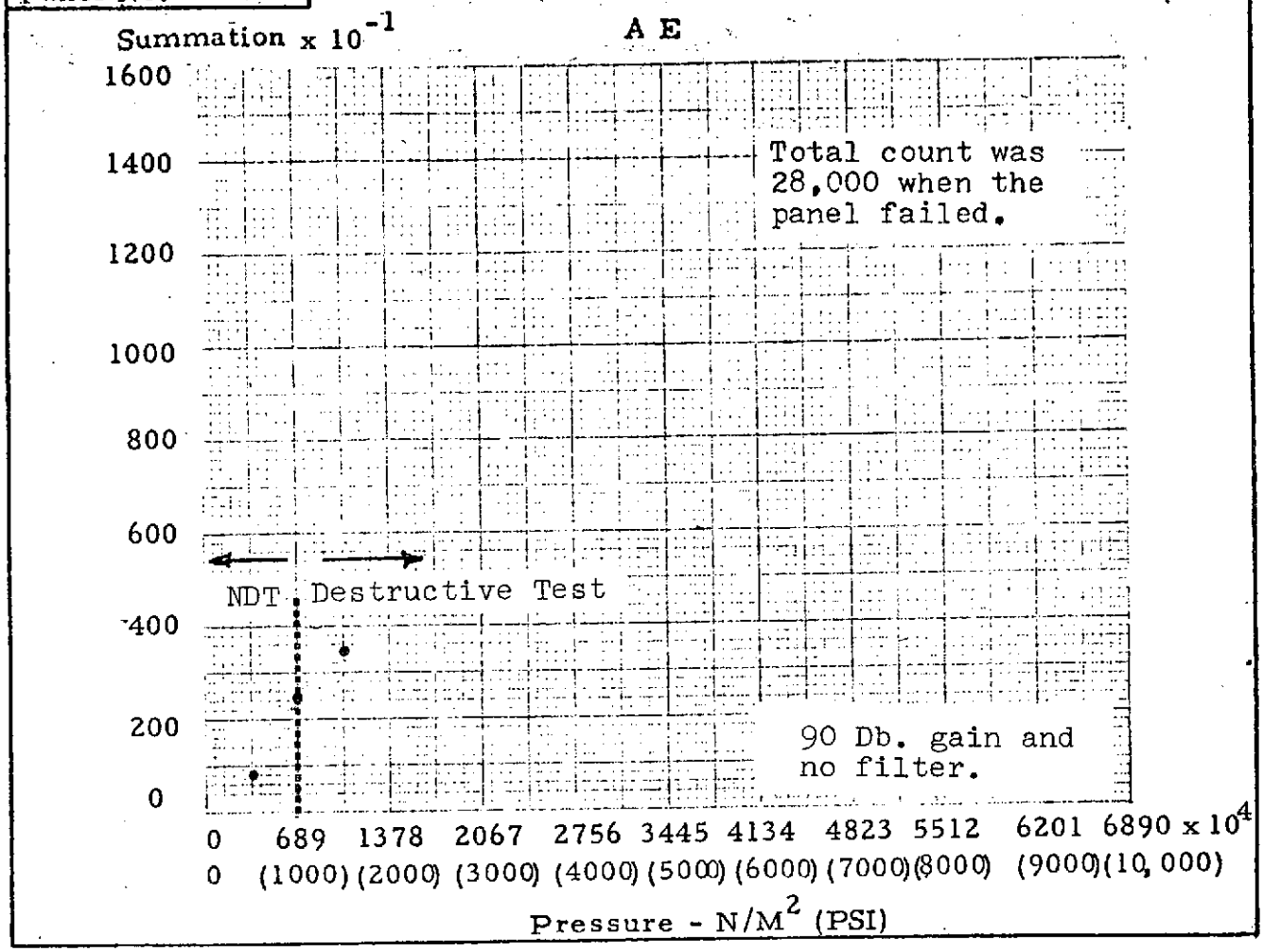
METALLOGRAPHIC ANALYSIS:

Section through the planned weak bond. Note separation as occurring between the initial copper deposit layer and subsequent build-up. Magnification 100X.

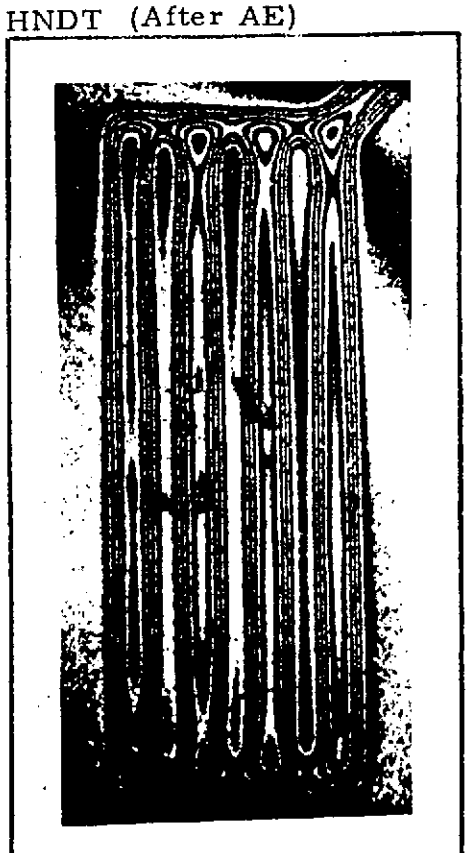
Section showing the full bond near the planned weak bond. Magnification 50X.

FIGURE C-41

Panel No. C-19C

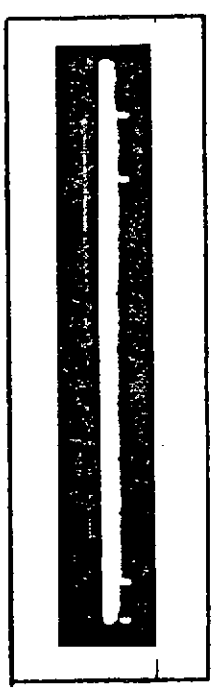


HNDT (After AE)

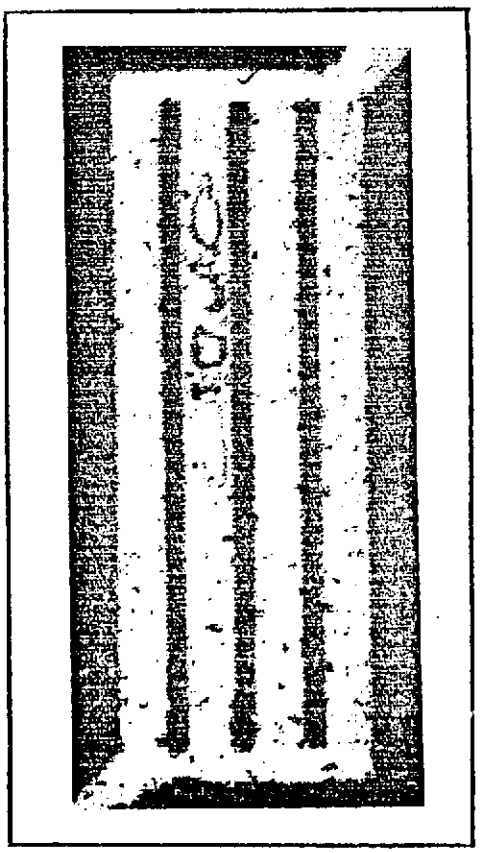


Press. 27.6 x 10^5 N/M^2
(400 PSI)

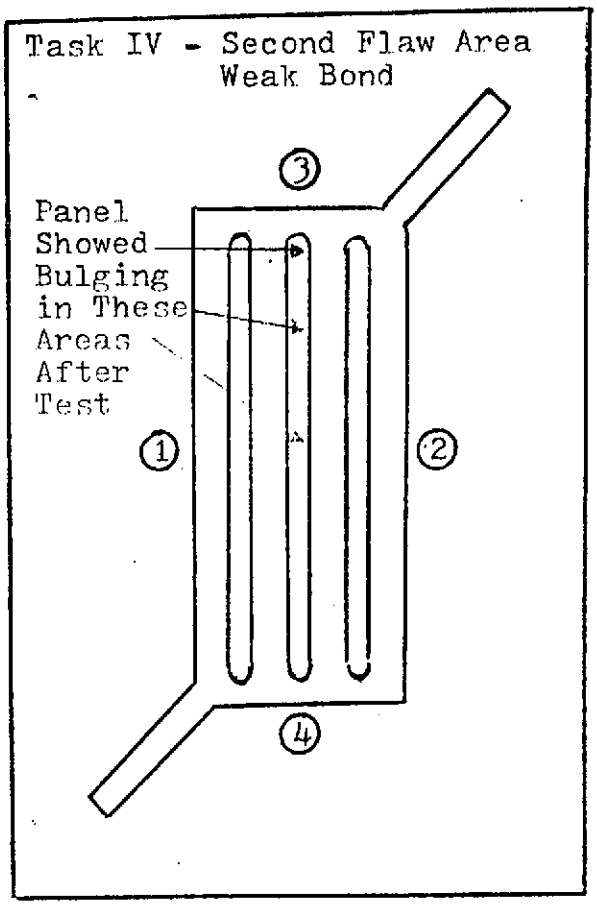
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-20C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.6040	0.2600
②	6.6396	0.2614
③	6.6243	0.2608
④	6.6091	0.2602

COVERPLATE

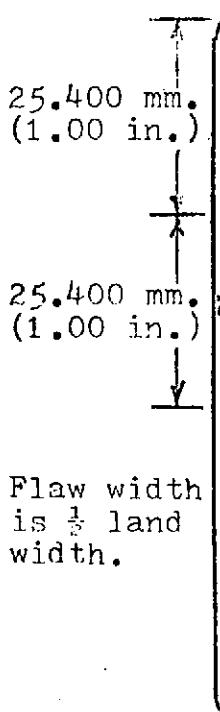
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2471	0.0491
②	1.2954	0.0510
③	1.3081	0.0515
④	1.2979	0.0511

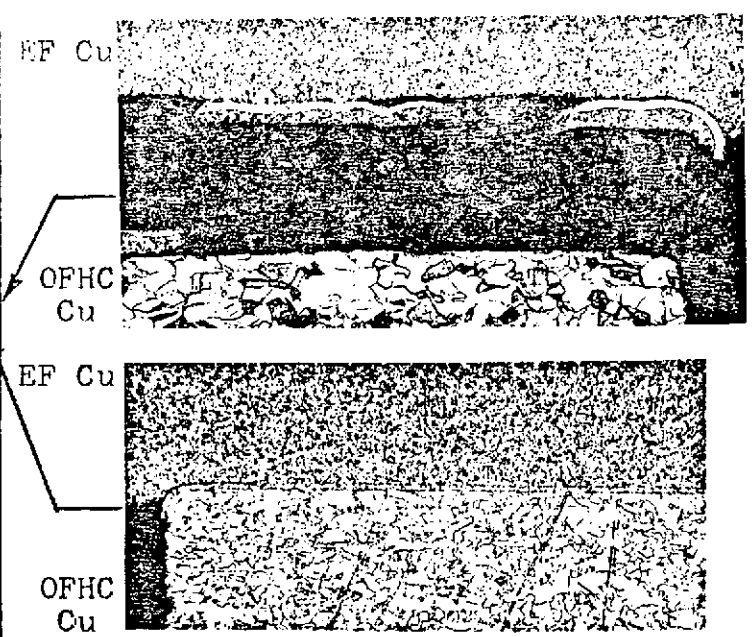
PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 1.31×10^7 N/m^2 (1,900 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

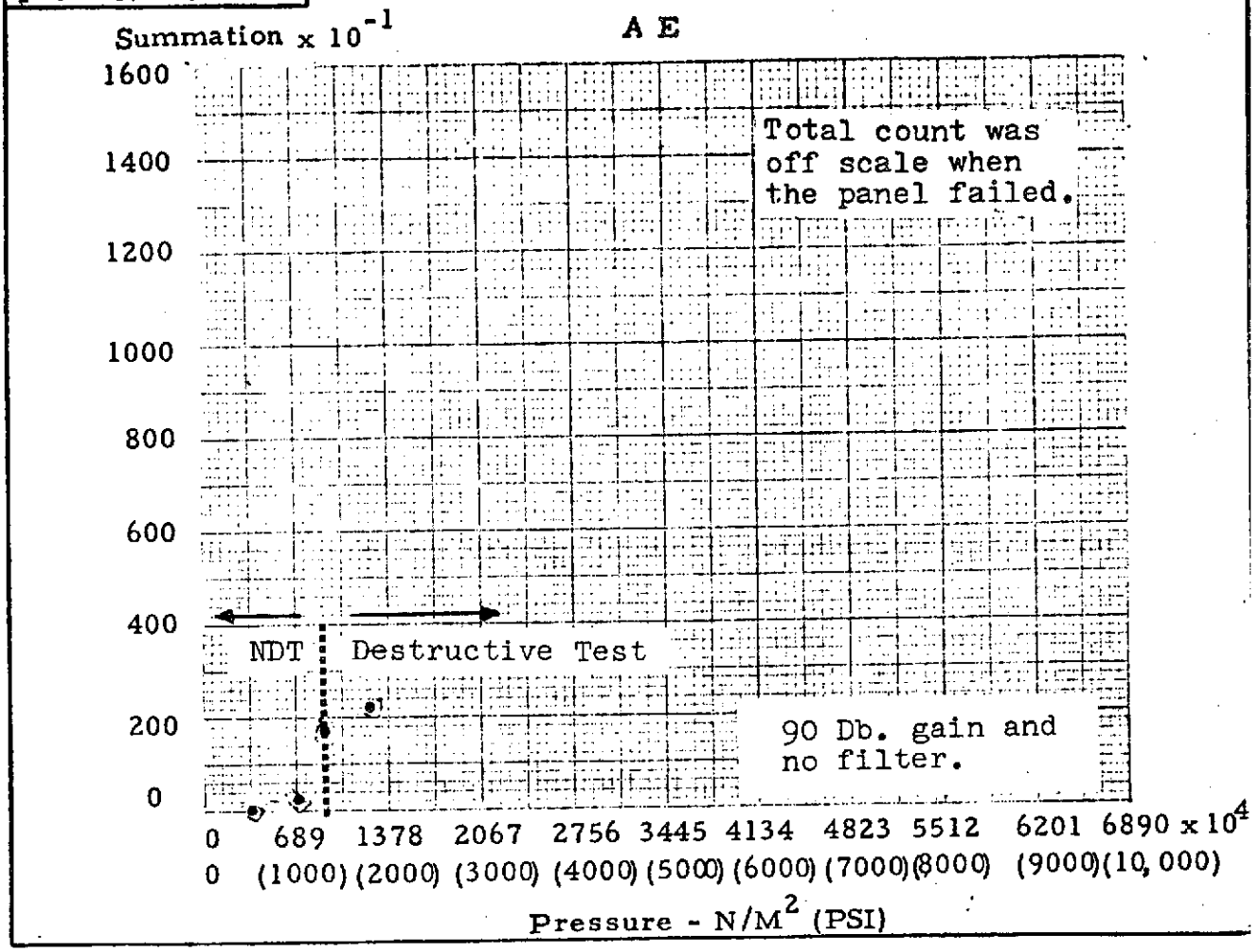


Section of the planned weak bond showing interface layer disturbance during failure. Magnification 100X.

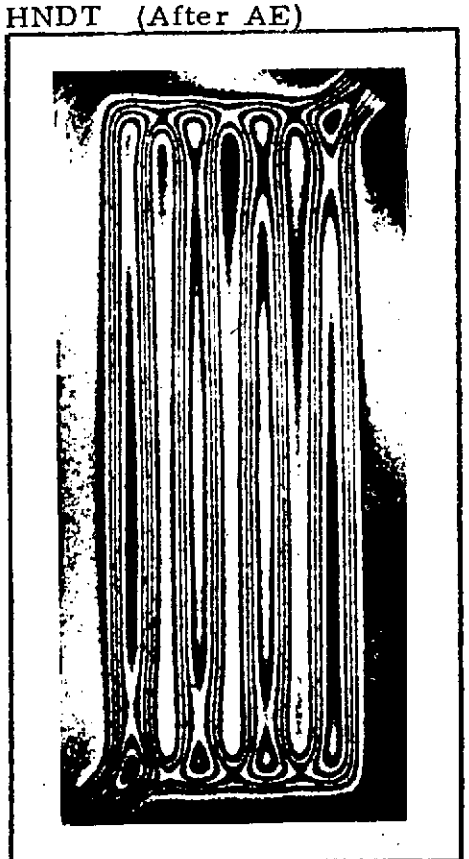
Section of the planned full bond adjacent to the weak bond. Magnification 50X.

FIGURE C-42

Panel No. C-20C

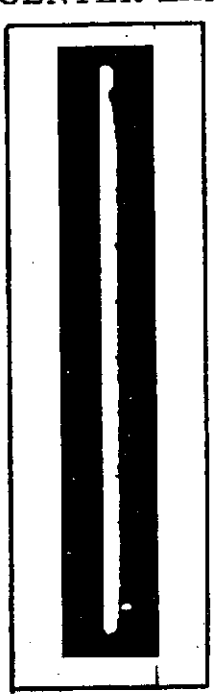


HNDT (After AE)

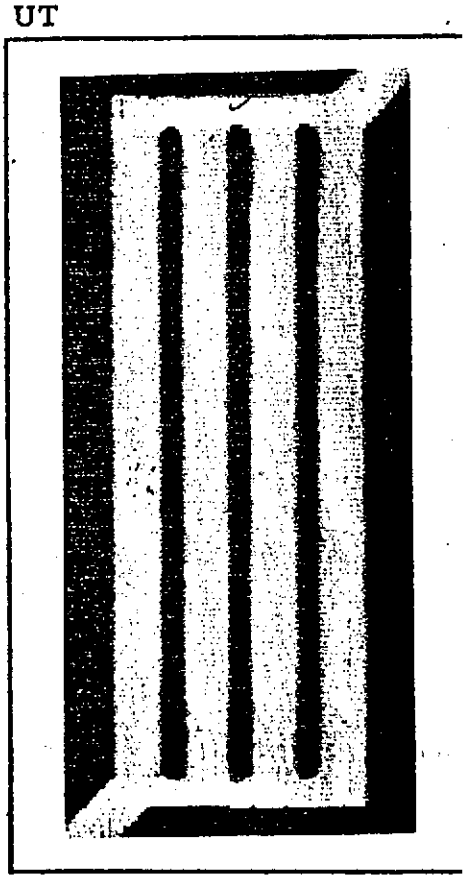


Press. 27.6 x 10^5 N/M^2
(400 PSI)

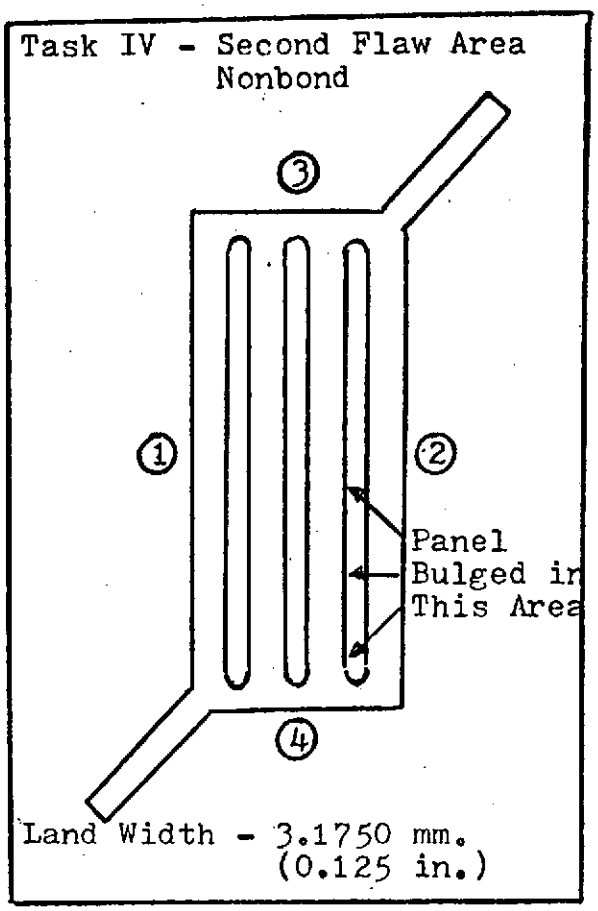
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-21C "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.006 in. (0.1524 mm.)

THICKNESS:	MM.	INCHES
①	6.3119	0.2485
②	6.2916	0.2477
③	6.3043	0.2482
④	6.3195	0.2488

COVERPLATE

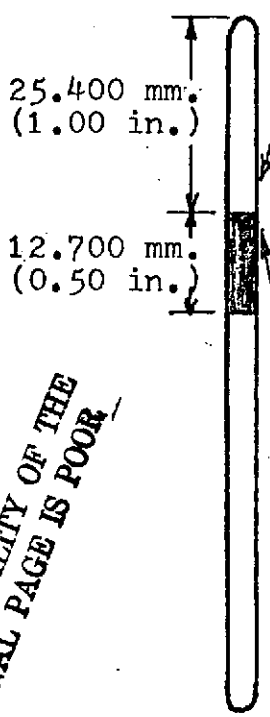
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2929	0.0509
②	1.2852	0.0506
③	1.3030	0.0513
④	1.2700	0.0500

PRESSURE REQUIRED TO FAIL BOND:

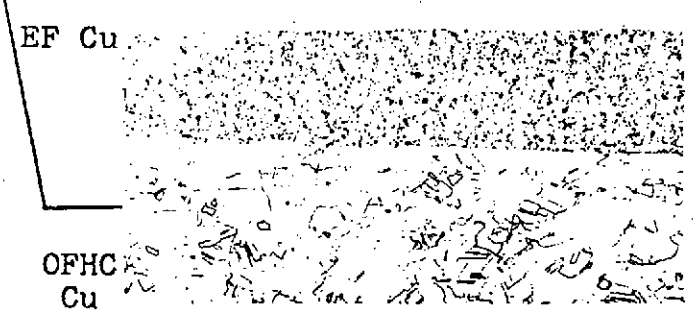
Panel failed at a pressure of 1.79×10^7 N/m^2 (2,600 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

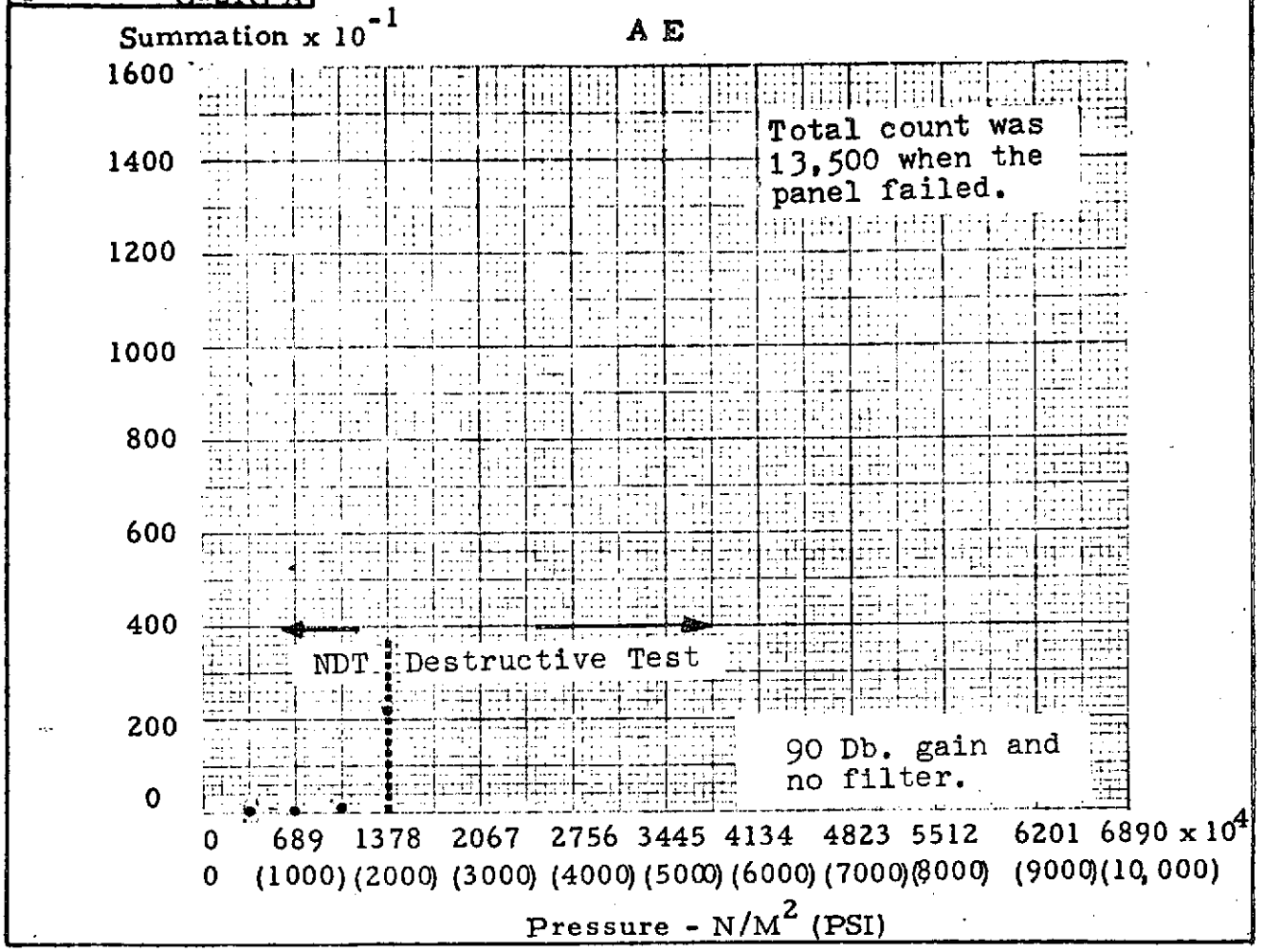
Section from the planned full bond area showing no failure after the destructive test. Magnification 100X.



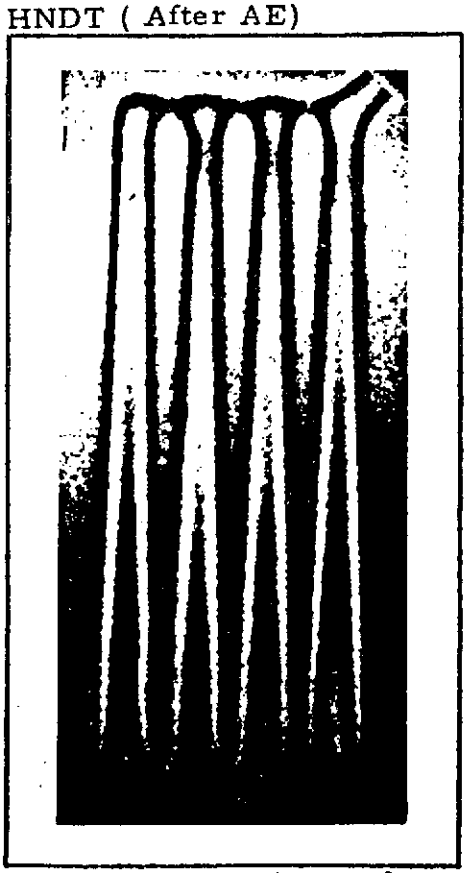
Section from the planned nonbond. The bondline has the appearance of a full or weak bond and shows no evidence of failure. Magnification 100X.

FIGURE C-43

Panel No. C-21C "A"

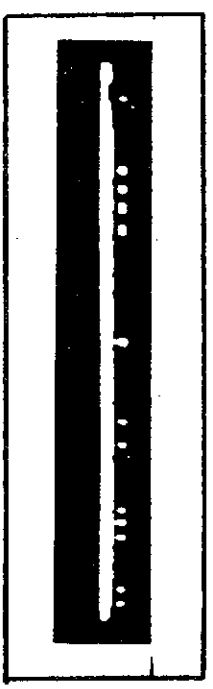


HNDT (After AE)

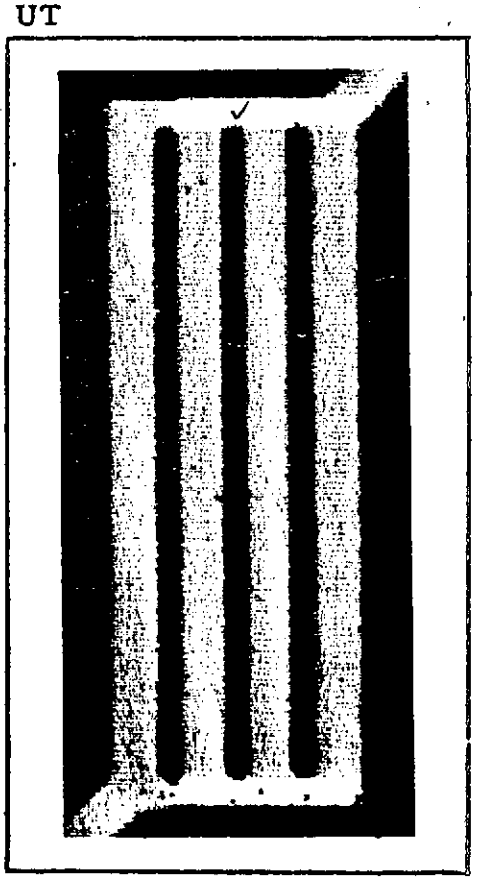


Press. 6.9×10^5 N/M^2
(100 PSI)

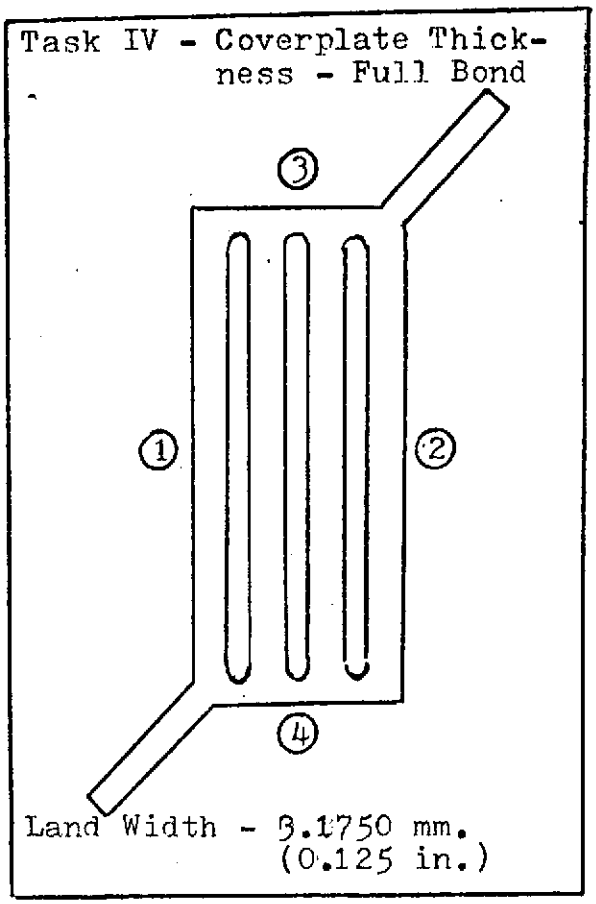
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-04C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.002 in. (0.0508 mm.)

THICKNESS:	MM.	INCHES
①	6.4465	0.2538
②	6.4567	0.2542
③	6.4719	0.2548
④	6.4033	0.2521

COVERPLATE

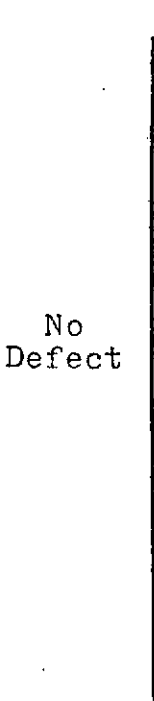
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	0.7620	0.0300
②	0.7036	0.0277
③	0.6379	0.0259
④	0.7772	0.0306

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 2.42×10^7 N/m^2 (3,500 psi).

CENTER LAND DEFECT

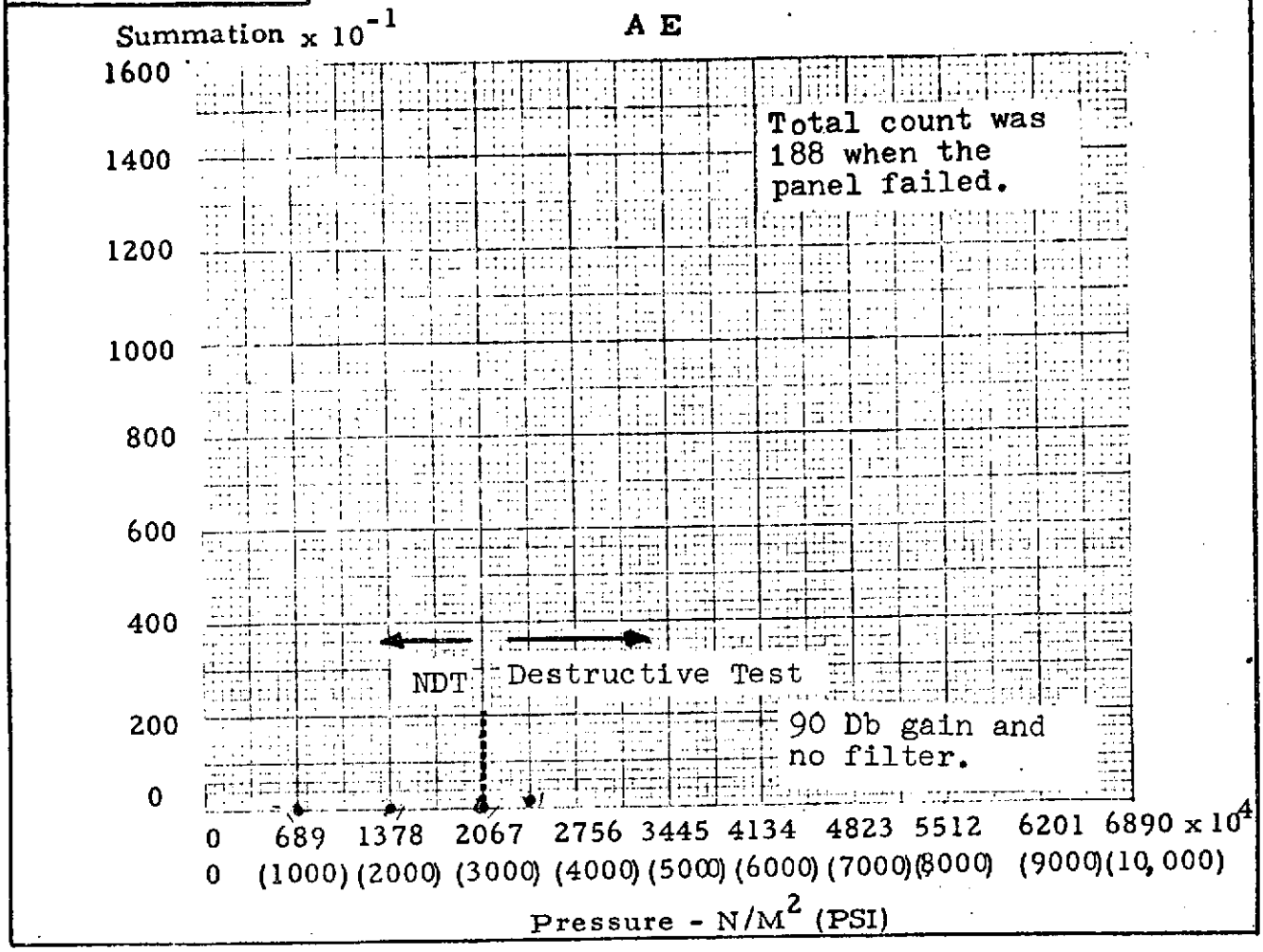


METALLOGRAPHIC ANALYSIS:

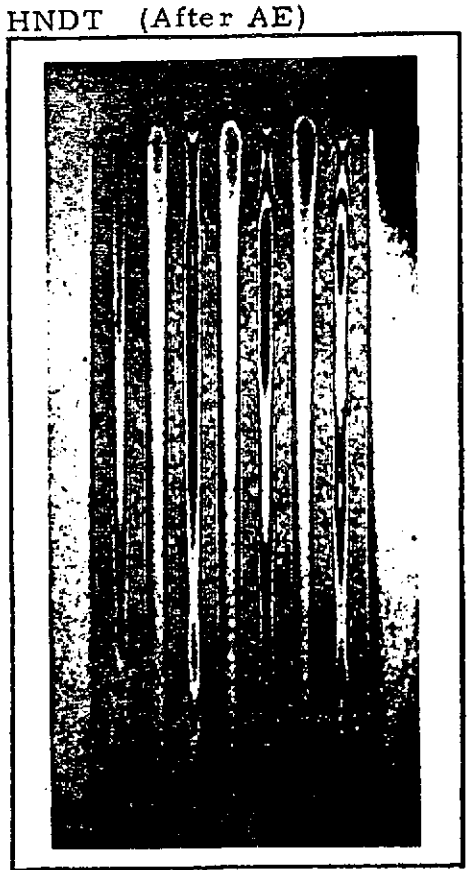
Section of full bond which did not fail. Note start of failure at edge of land. Magnification 100X.

FIGURE C-44

Panel No. C-4C

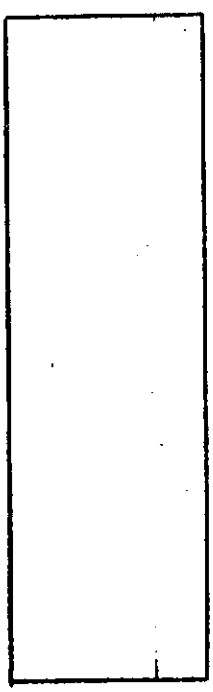


HNDT (After AE)

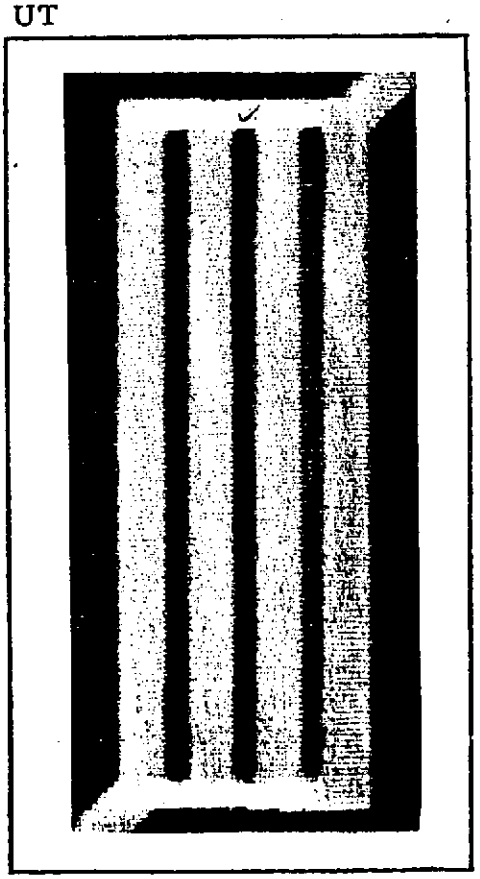


Press. 20.7 x 10^5 N/M^2
(300 PSI)

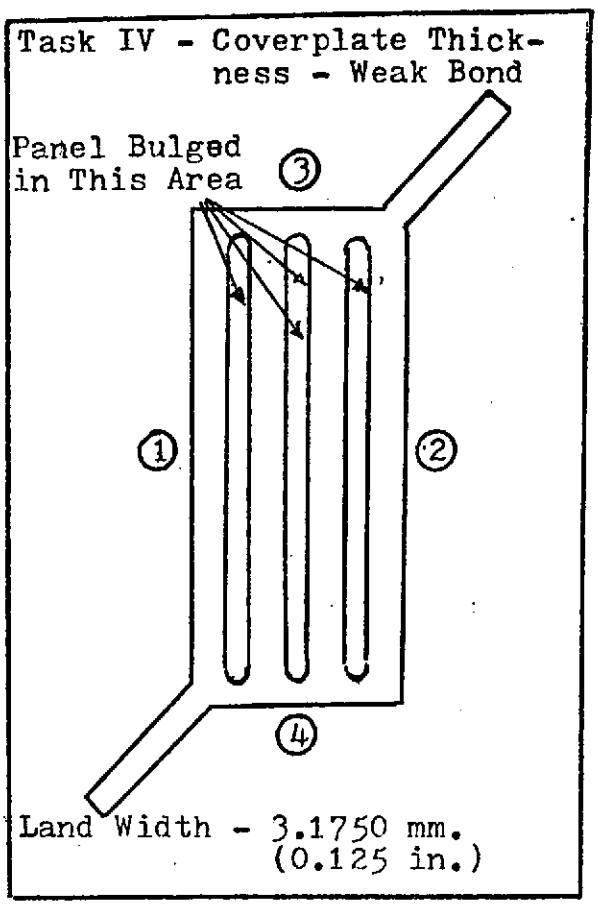
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-22C "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.0015 in. (0.0381 mm.)

THICKNESS:	MM.	INCHES
①	6.3830	0.2513
②	6.4084	0.2523
③	6.4287	0.2531
④	6.4211	0.2528

COVERPLATE

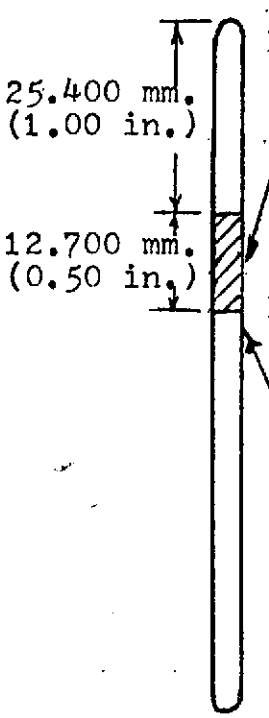
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	0.7239	0.0285
②	0.6960	0.0274
③	0.7341	0.0289
④	0.6985	0.0275

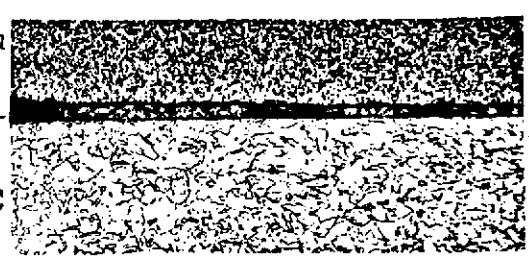
PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 0.97×10^7 N/m^2 (1,400 psi).

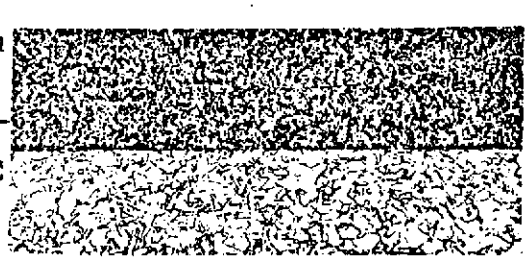
CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



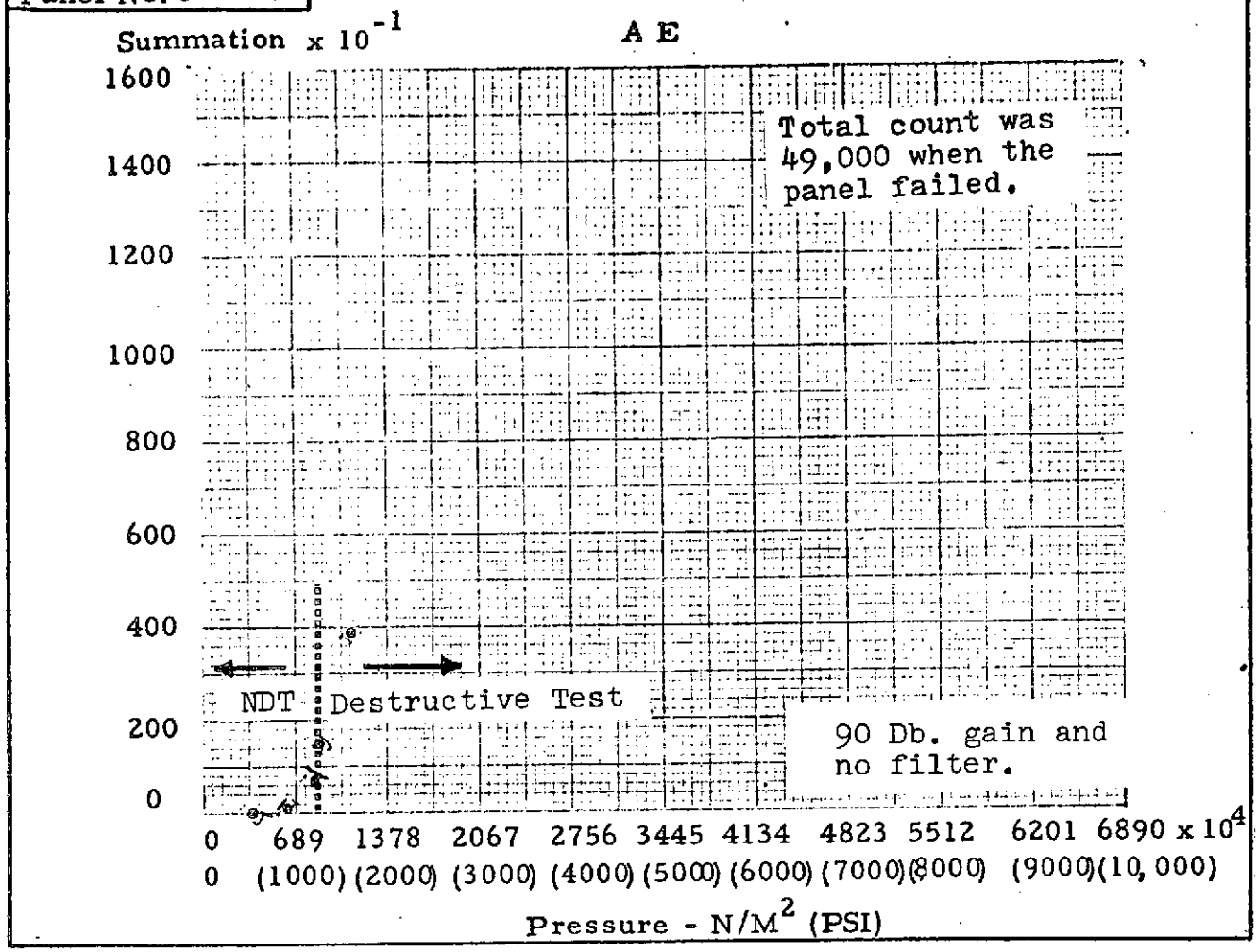
Section showing failure in planned weak bond region. Magnification 50X.



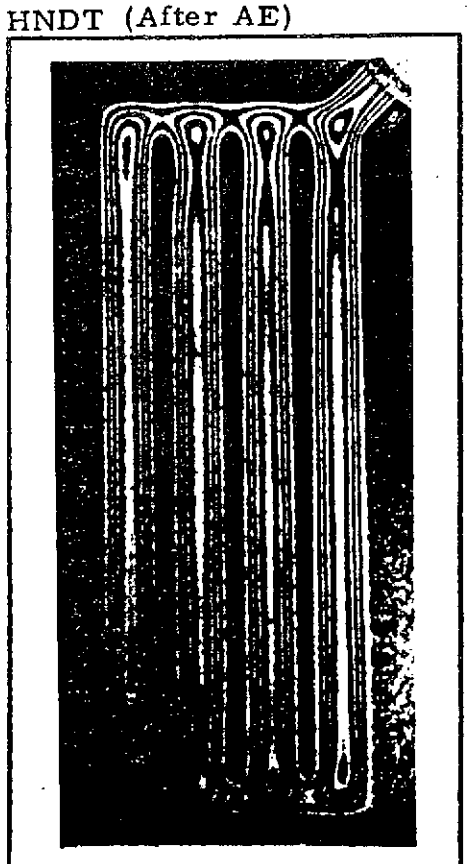
Full bond region adjacent to the planned weak bond. No failure was noted. Magnification 50X.

FIGURE C-45

Panel No. C-22"A"

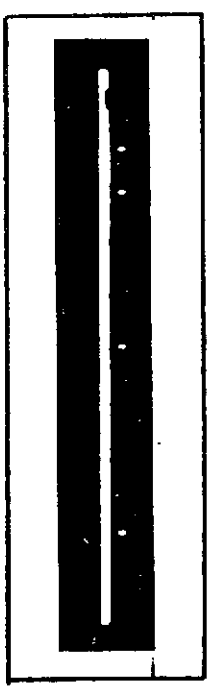


HNDT (After AE)

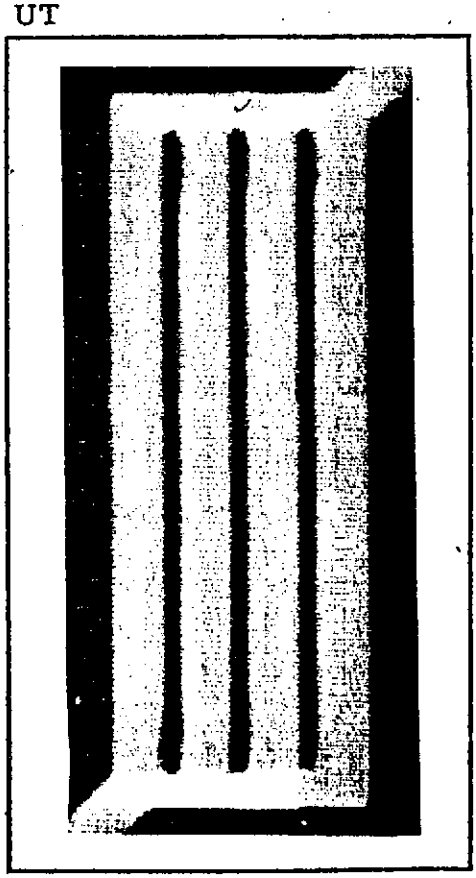


Press. 6.9×10^5 N/M^2
(100 PSI)

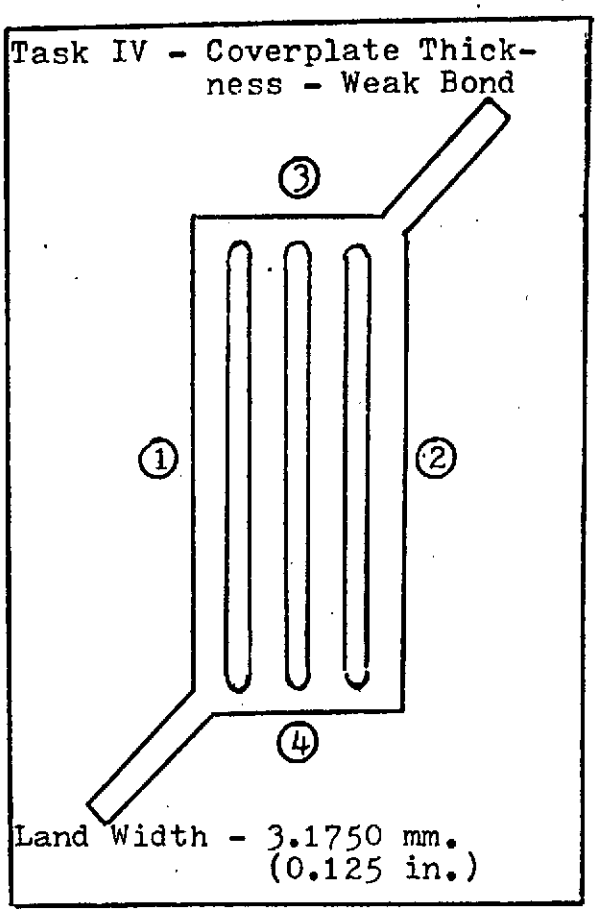
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-23C "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.0025 in. (0.0635 mm.)

THICKNESS:	MM.	INCHES
①	6.5227	0.2568
②	6.5253	0.2569
③	6.4821	0.2552
④	6.5608	0.2583

COVERPLATE

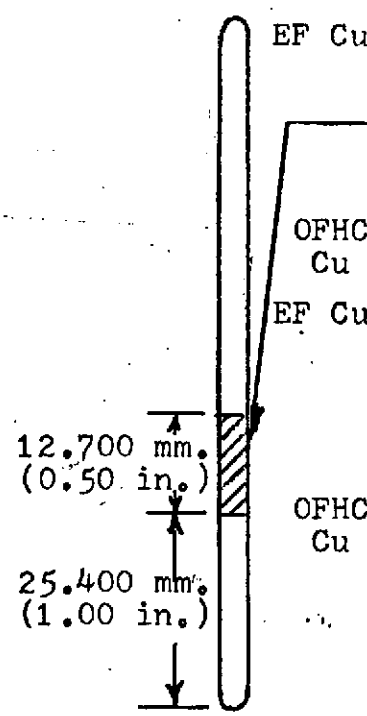
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	0.8001	0.0315
②	0.7417	0.0292
③	0.7671	0.0302
④	0.7493	0.0295

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 1.59×10^7 N/m^2 (2,300 psi).

CENTER LAND DEFECT



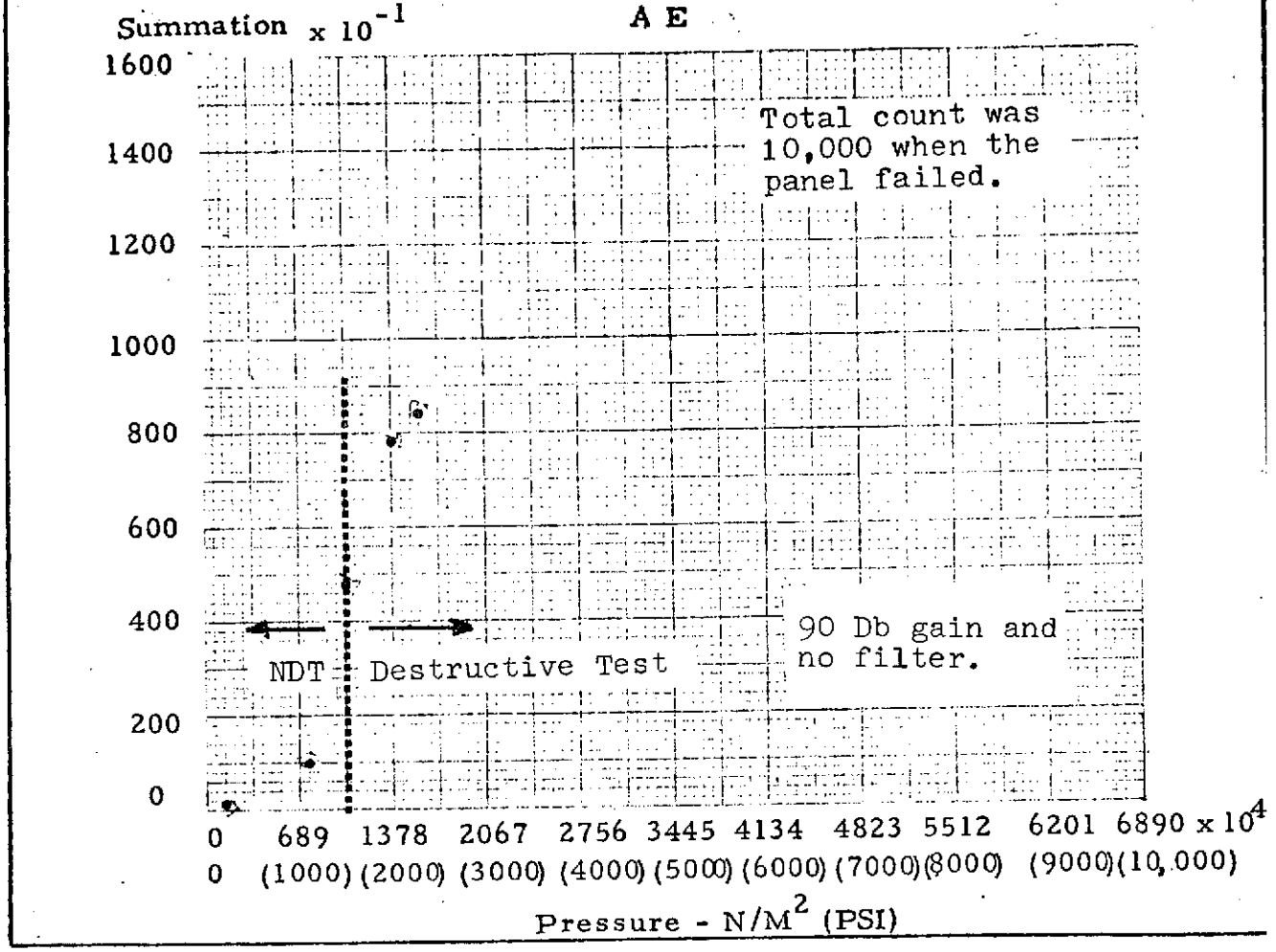
METALLOGRAPHIC ANALYSIS:

Section of the planned weak bond showing no failure. Coverplate failed at too low a pressure to fail bond. Magnification 50X.

Section of planned full bond on Land 3 adjacent to the Land 2 weak bond. Magnification 50X.

FIGURE C-46

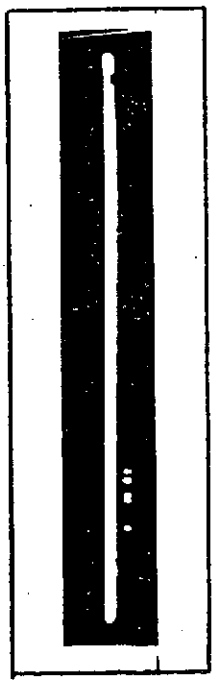
Panel No.C-23C"A"



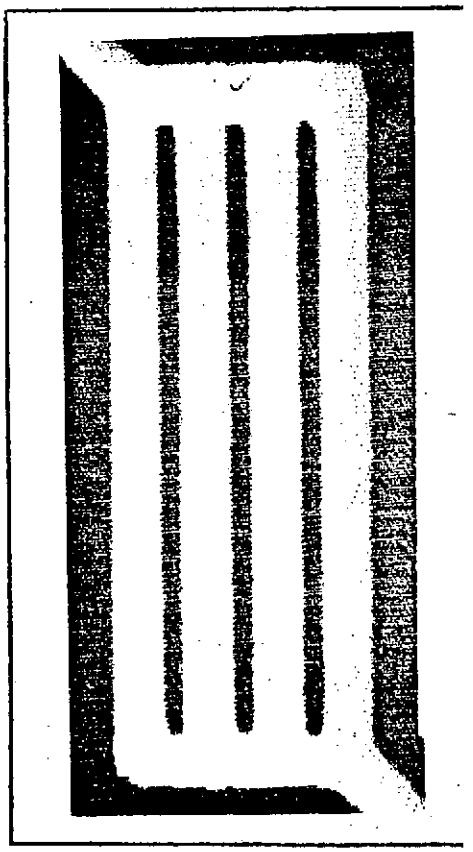
HNDT (Before AE)

Press. 6.9 x 10^5 N/M^2
(100 PSI)

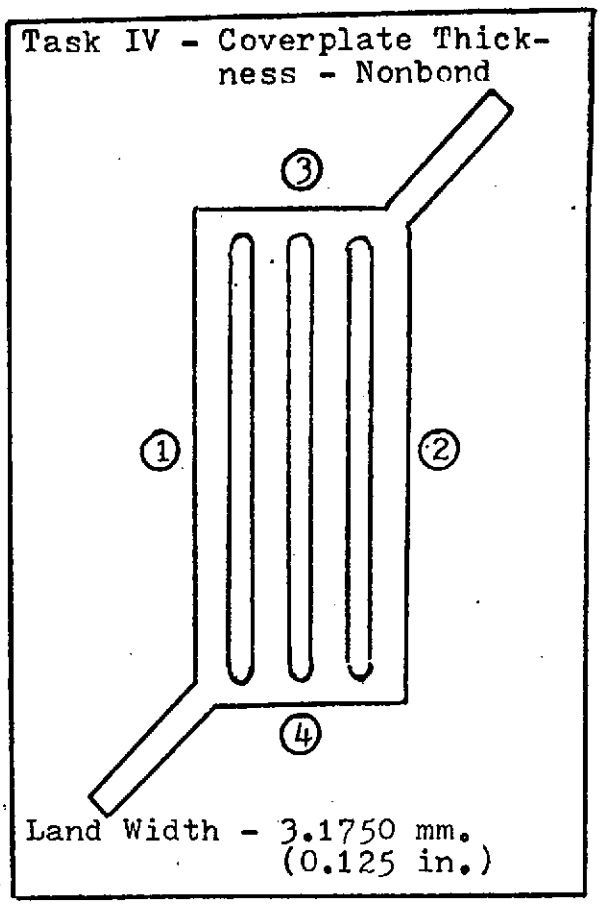
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-24C "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.4770	0.2550
②	6.4821	0.2552
③	6.4897	0.2555
④	6.5024	0.2560

COVERPLATE

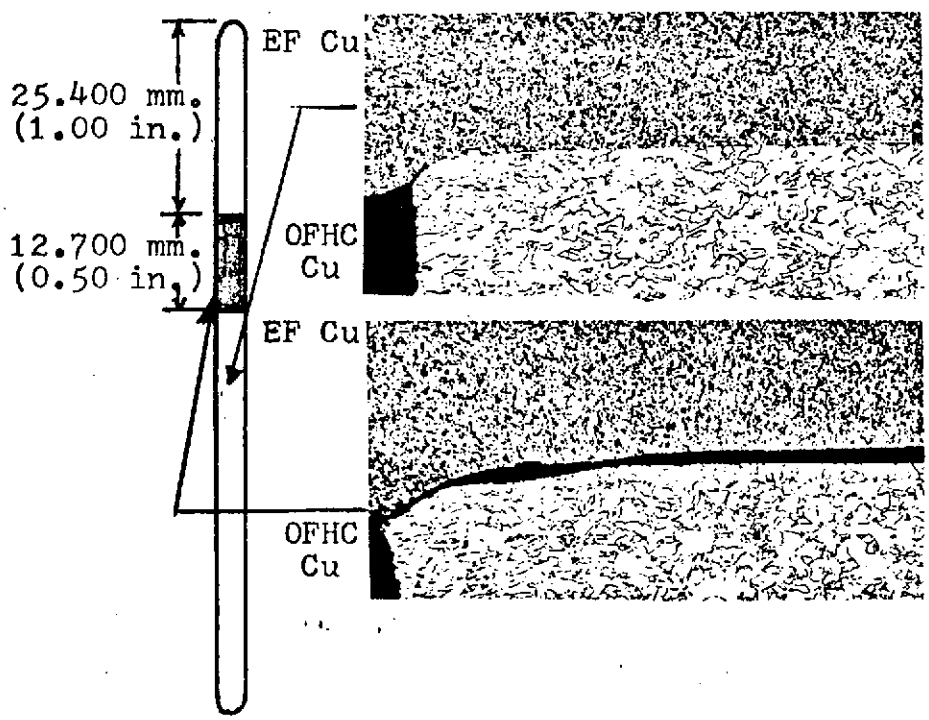
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	0.7163	0.0282
②	0.7239	0.0285
③	0.7366	0.0290
④	0.6934	0.0273

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 0.76×10^7 N/m^2 (1,100 psi).

CENTER LAND DEFECT METALLOGRAPHIC ANALYSIS:

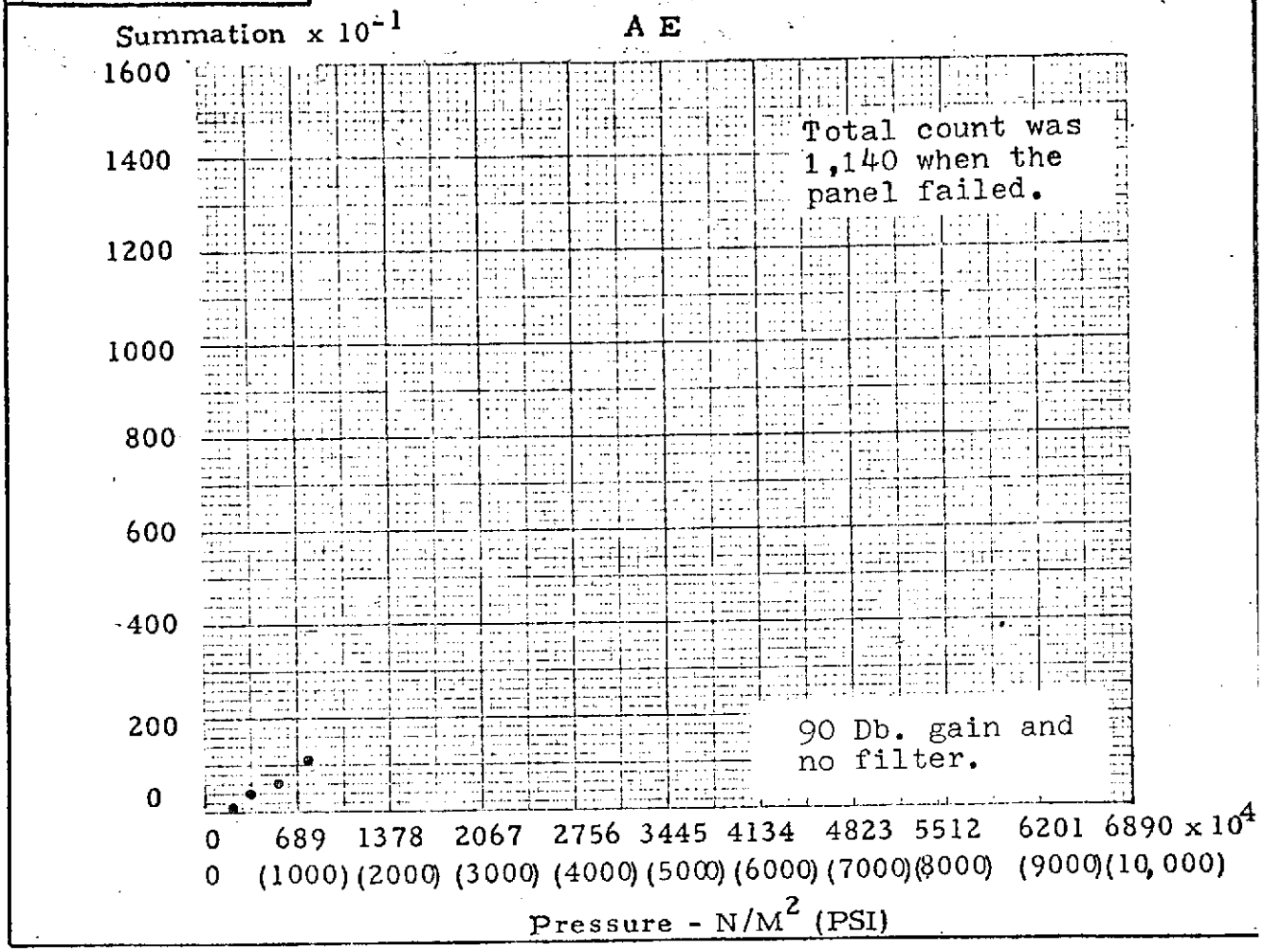


Full bond area next to planned nonbond. Note initiation of failure at land edge. Magnification 50X.

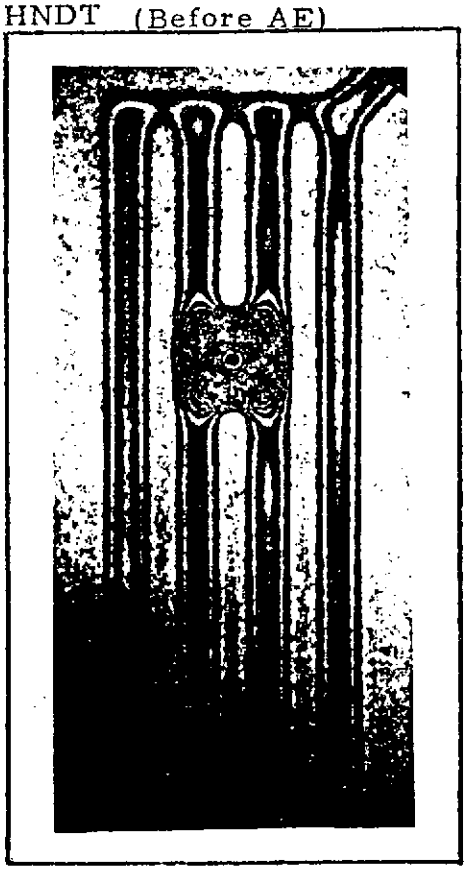
Separation of the planned nonbond. No metal disturbance was noted. Magnification 50X.

FIGURE C-47

Panel No. C-24C



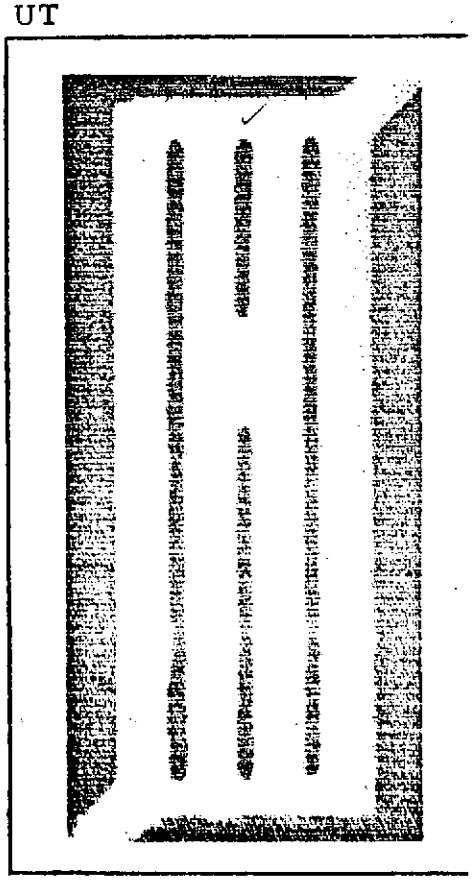
HNDT (Before AE)



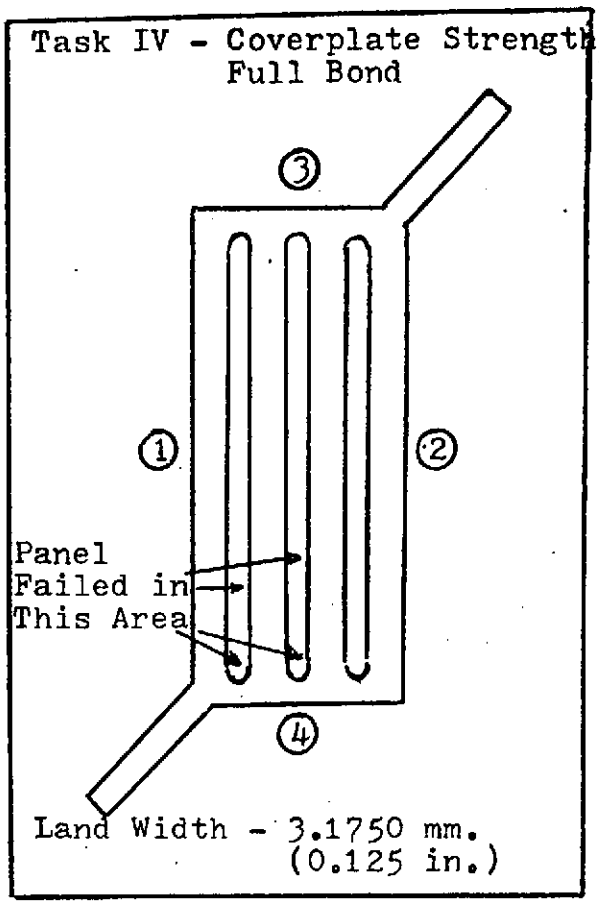
Press. 3.45 x 10^5 N/M^2 (50 PSI)

AE FLAW LOCATOR CENTER LAND

UT



ELECTROFORMED PANEL NO. C-12C "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	5.9665	0.2349
②	5.9639	0.2348
③	5.9588	0.2346
④	5.9258	0.2333

COVERPLATE

MATERIAL: Electroformed Copper

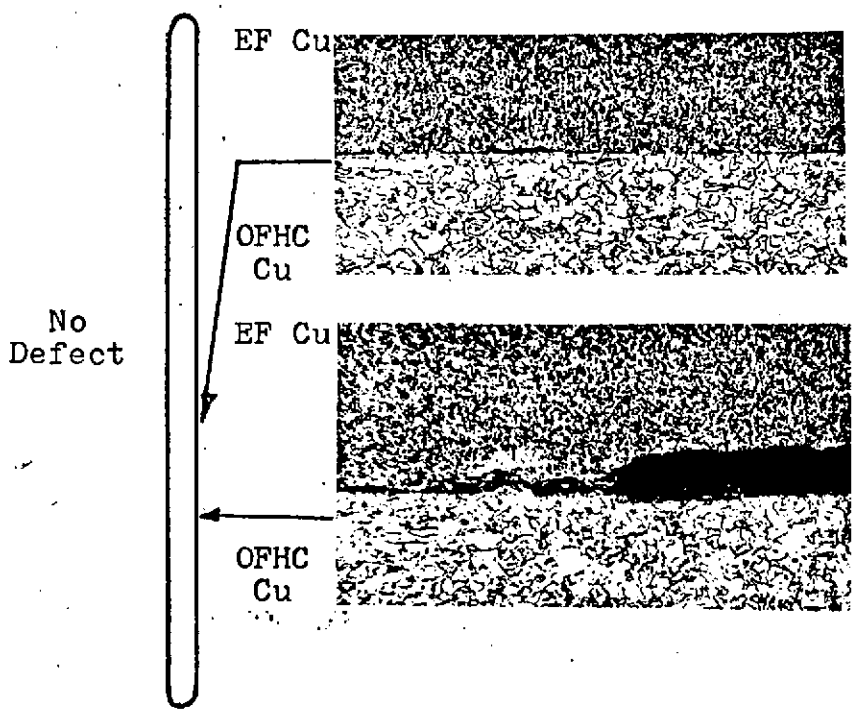
THICKNESS:	MM.	INCHES
①	1.2040	0.0474
②	1.1811	0.0465
③	1.1760	0.0463
④	1.2294	0.0484

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 3.80×10^7 N/m^2 (5,500 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

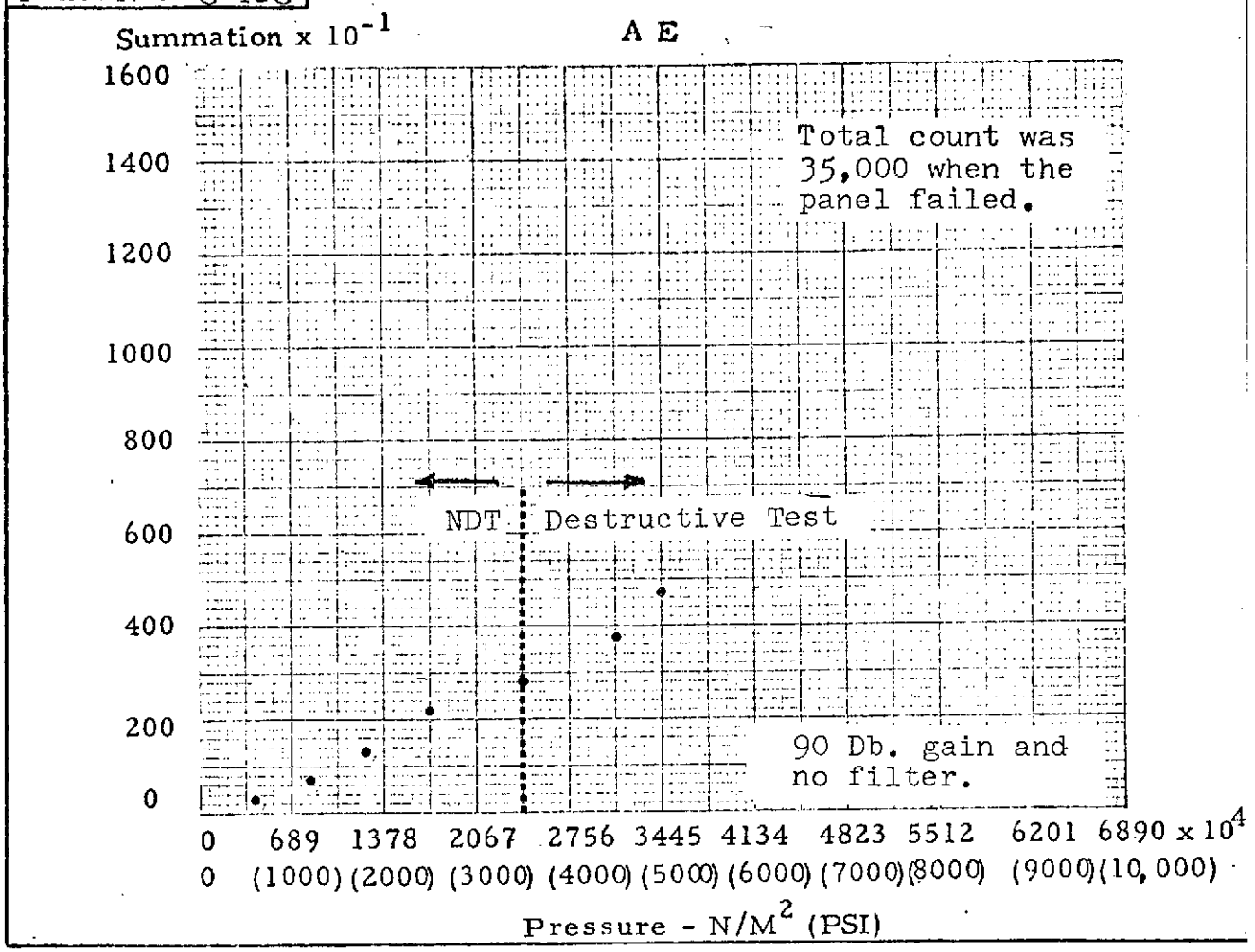


Planned full bond region. Bond line appears to contain intermittent areas of failure initiation. Magnification 50X.

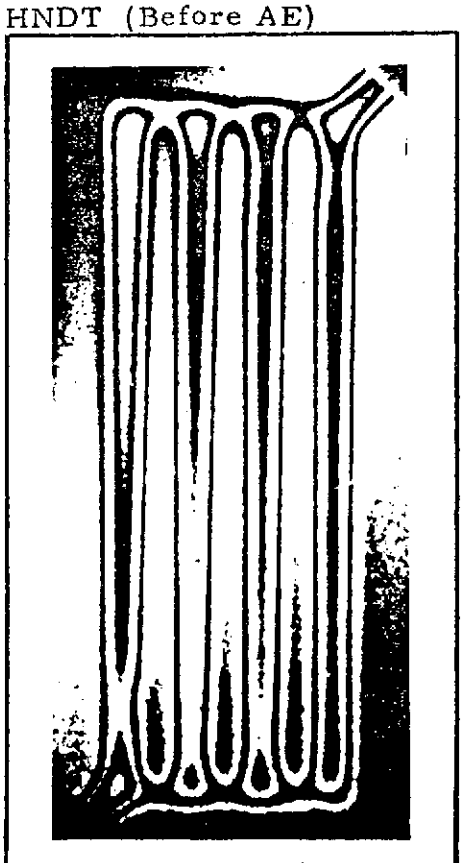
Planned full bond which failed during destructive test. Magnification 50X.

FIGURE C-48

Panel No. C-12C

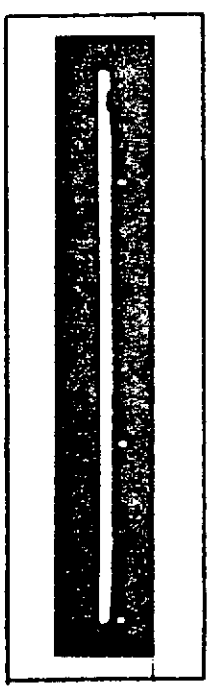


HNDT (Before AE)

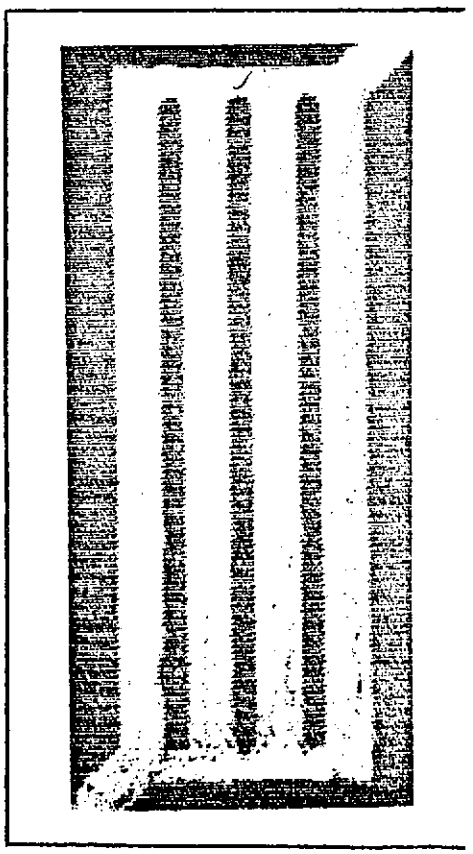


Press. - 13.8 x 10^5 N/M^2
(200 PSI)

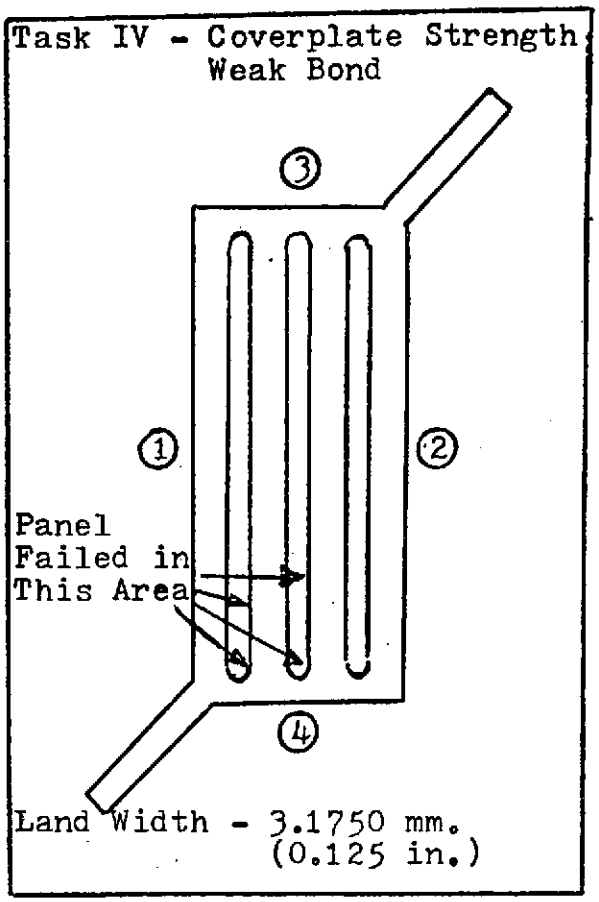
AE
FLAW LOCATOR
CENTER LAND



UT



ELECTROFORMED PANEL NO. C-25C "A"



BASEPLATE

MATERIAL: DFHC Copper

CENTER LAND FLATNESS VARIATION:
0.003 in. (0.0762 mm.)

THICKNESS:	MM.	INCHES
①	6.1570	0.2424
②	6.1468	0.2420
③	6.1722	0.2430
④	6.2026	0.2442

COVERPLATE

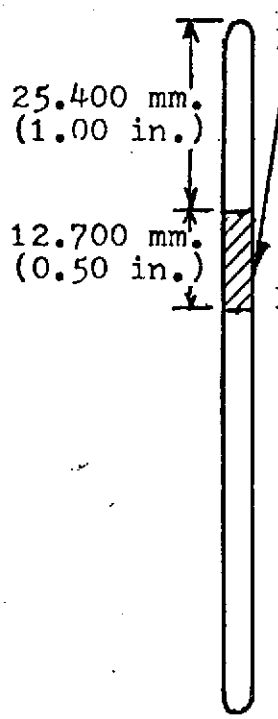
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2243	0.0482
②	1.2141	0.0478
③	1.1862	0.0467
④	1.1938	0.0470

PRESSURE REQUIRED TO FAIL BOND:

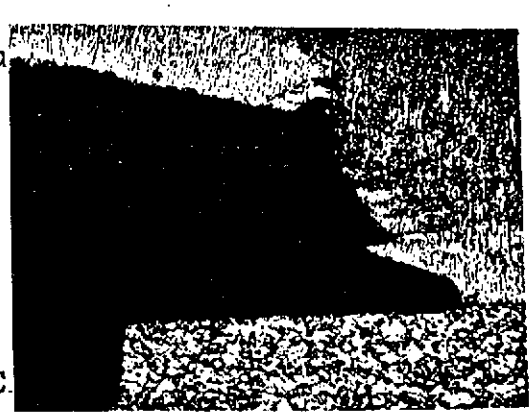
Panel failed at a pressure of 3.93×10^7 N/m^2 (5,700 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

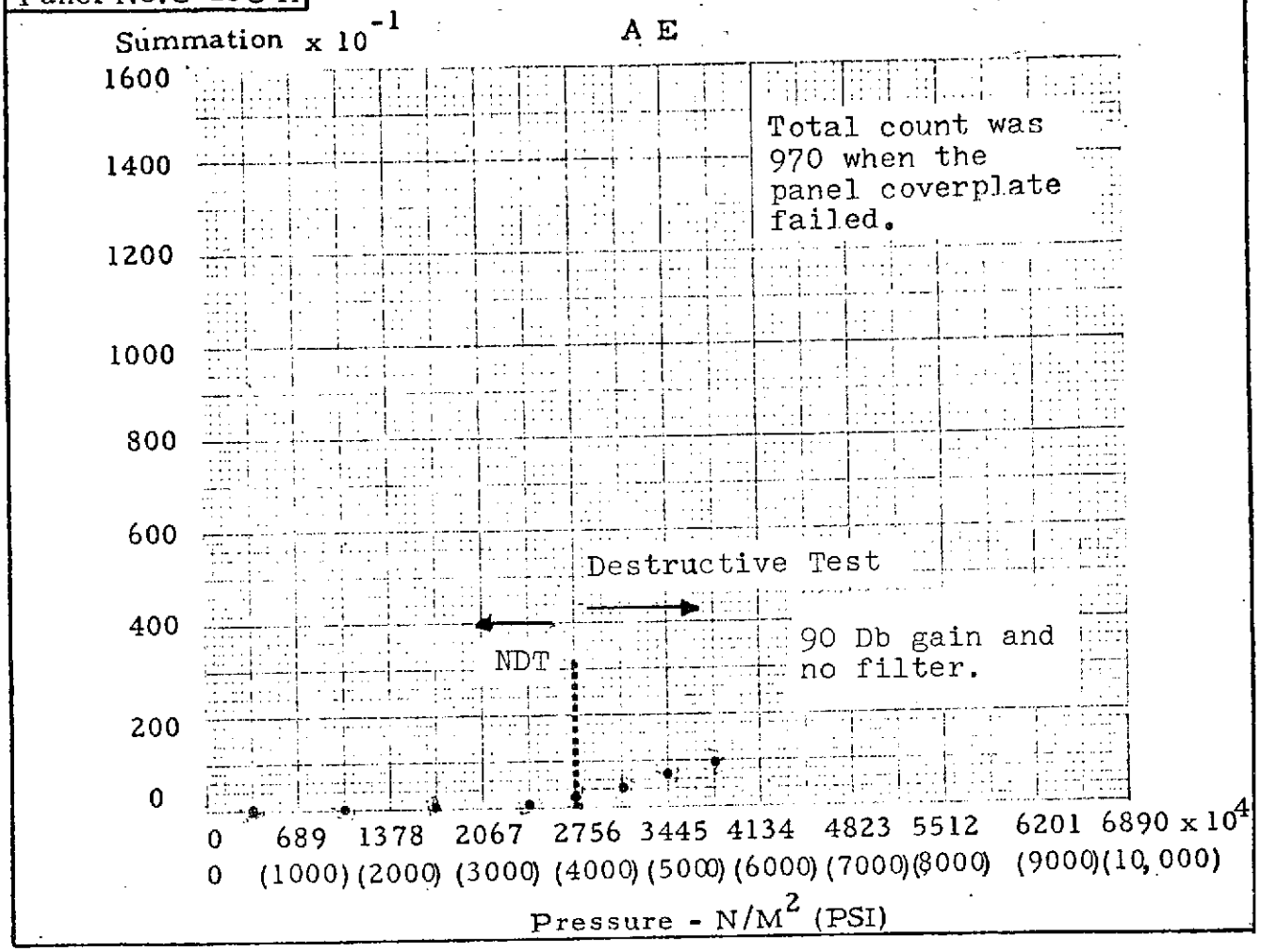
Section from planned weak bond indicates a full bond actually was obtained. No signs of failure are noted. Magnification 500X.



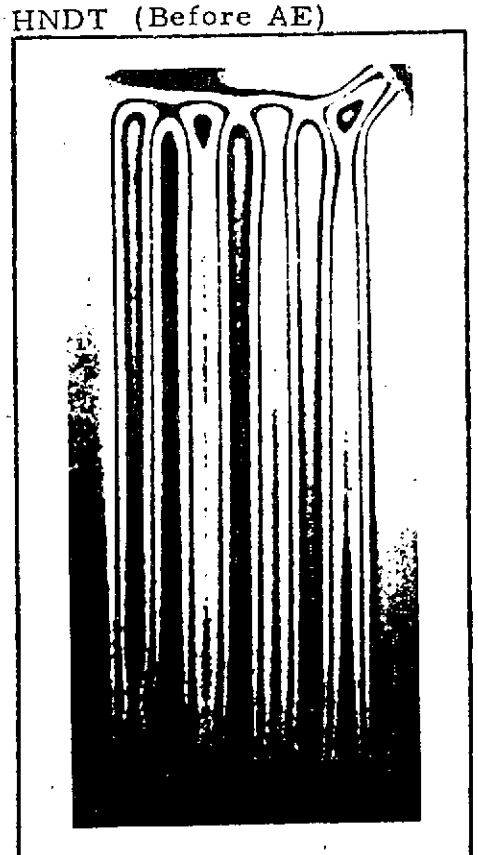
Panel failed in lower part of Land 1 and the manifold. Note failure occurred through an unplanned weak bond on one side of the land and tore through the copper coverplate. Magnification 32X.

FIGURE C-49

Panel No.C-25C'A'



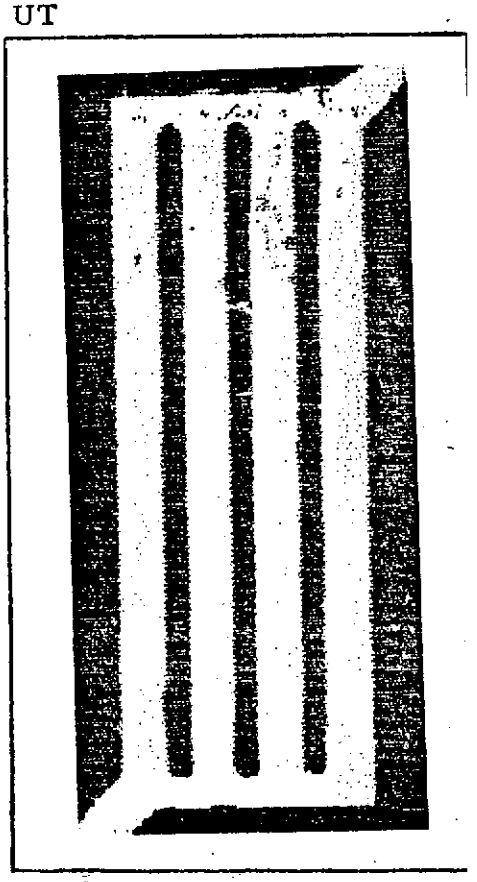
HNDT (Before AE)



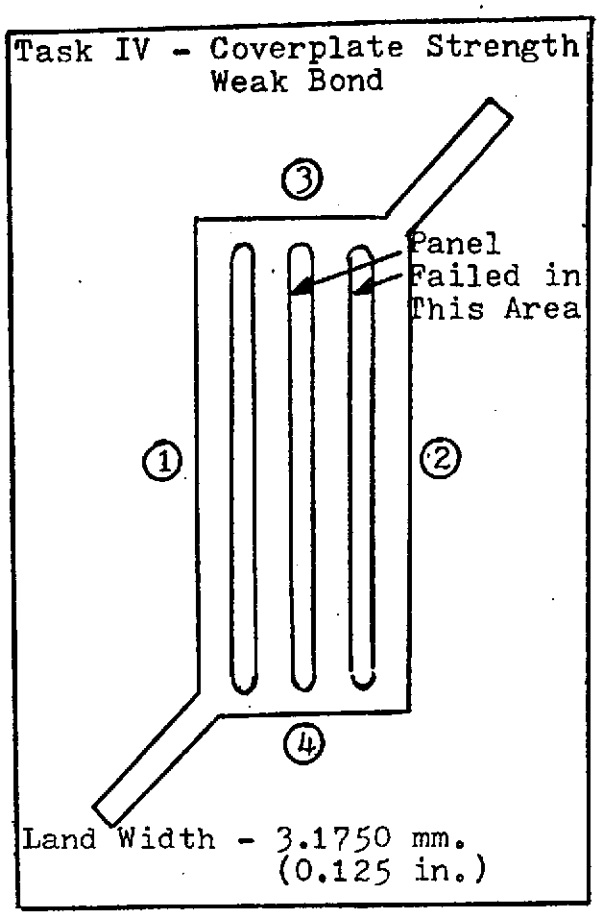
Press. 13. 8 x 10^5 N/M^2
(200 PSI)

AE
FLAW LOCATOR
CENTER LAND

UT



ELECTROFORMED PANEL NO. C-26C "A"



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: None detected.

THICKNESS:	MM.	INCHES
①	6.0706	0.2390
②	6.0706	0.2390
③	6.0884	0.2397
④	6.0655	0.2388

COVERPLATE

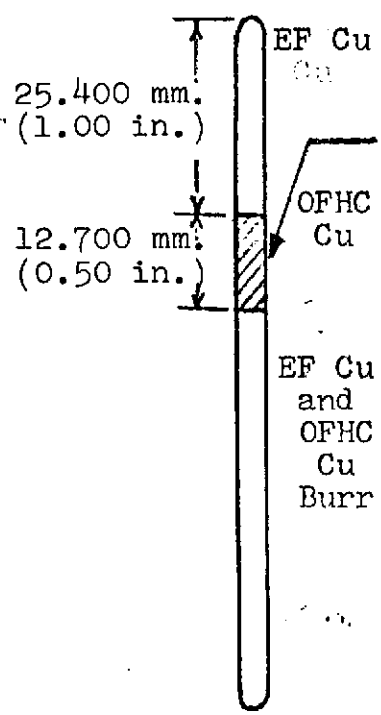
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2040	0.0474
②	1.2268	0.0483
③	1.1938	0.0470
④	1.2141	0.0478

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 5.18×10^7 N/m^2 (7,500 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

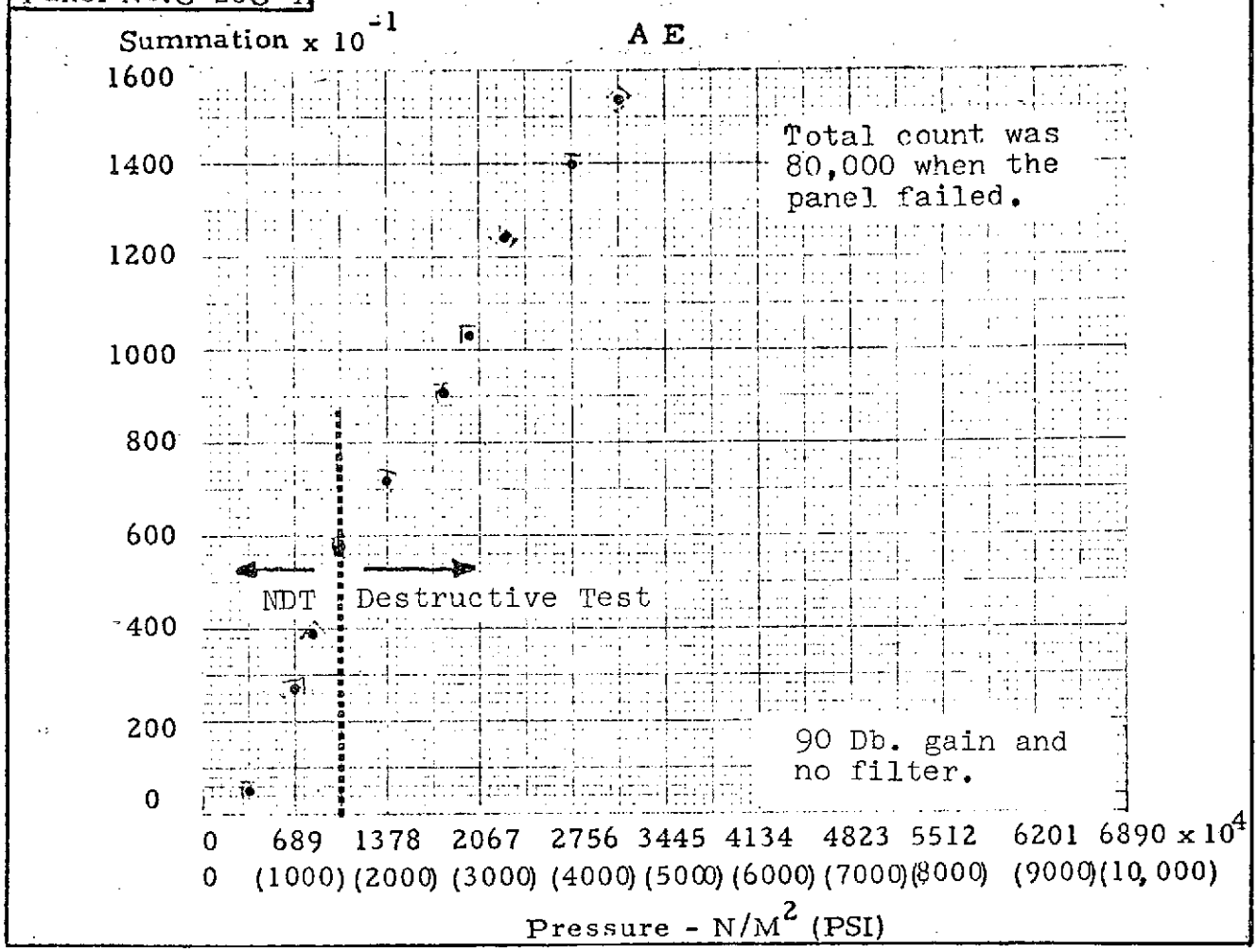
From Center Land

From Failed Land 3

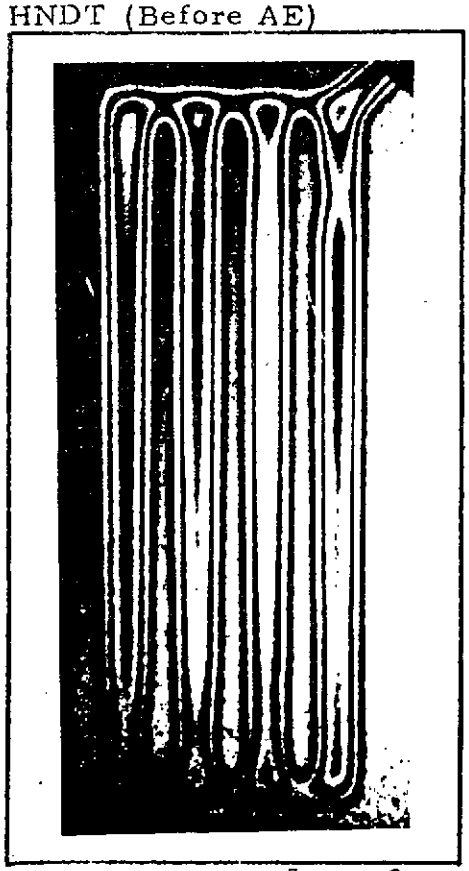
Because of a large unplanned nonbond noted on the original panel, the baseplate was machined to remove the old cover. The baseplate had burrs from the machining which were not completely removed by pickling. When the new coverplate was fabricated, the burrs failed under pressure and gave the false conception of a weak bond. The planned weak bond did not fail nor show any evidence of failing. Magnification 50X.

FIGURE C-50

Panel No. C-26C "A"



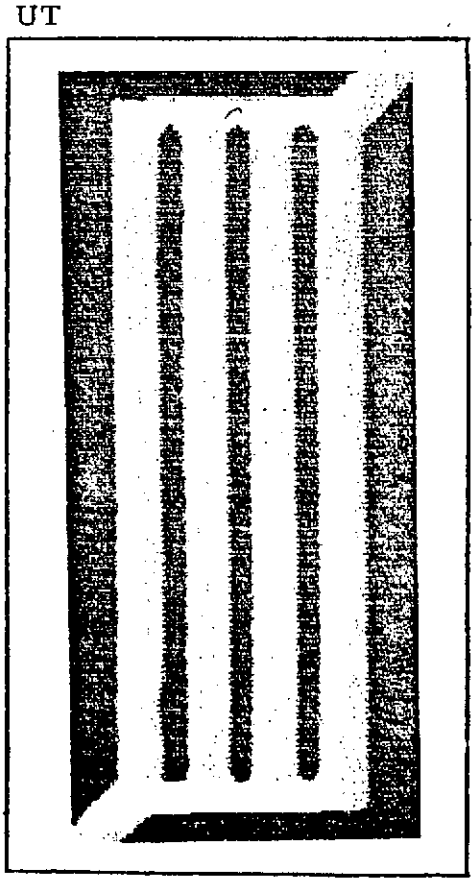
HNDT (Before AE)



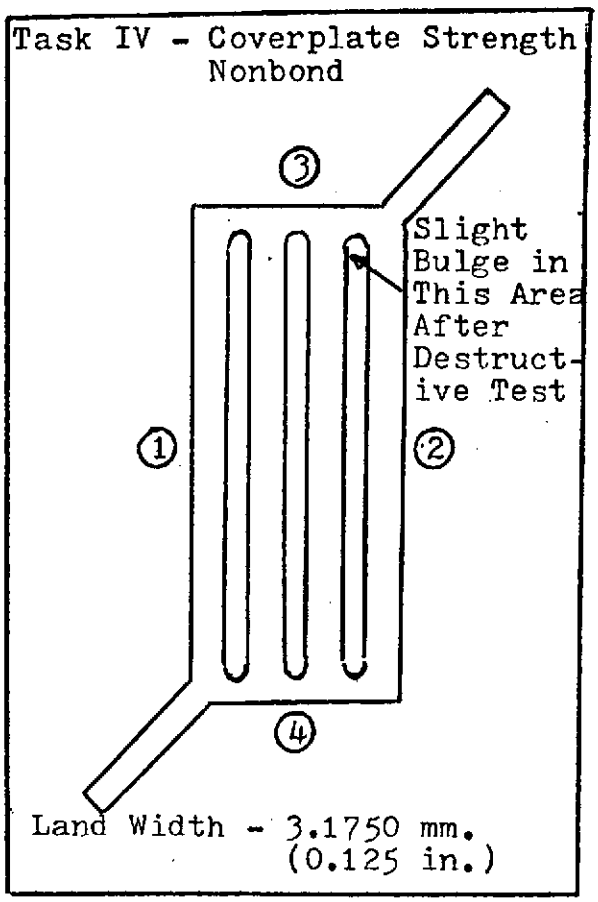
Press. 13.8 x 10^5 N/M^2
(200 PSI)

AE
FLAW LOCATOR
CENTER LAND

UT



ELECTROFORMED PANEL NO. C-27C



BASEPLATE

MATERIAL: OFHC Copper

CENTER LAND FLATNESS VARIATION: 0.001 in. (0.0254 mm.)

THICKNESS:	MM.	INCHES
①	6.4160	0.2526
②	6.4110	0.2524
③	6.3856	0.2514
④	6.4110	0.2524

COVERPLATE

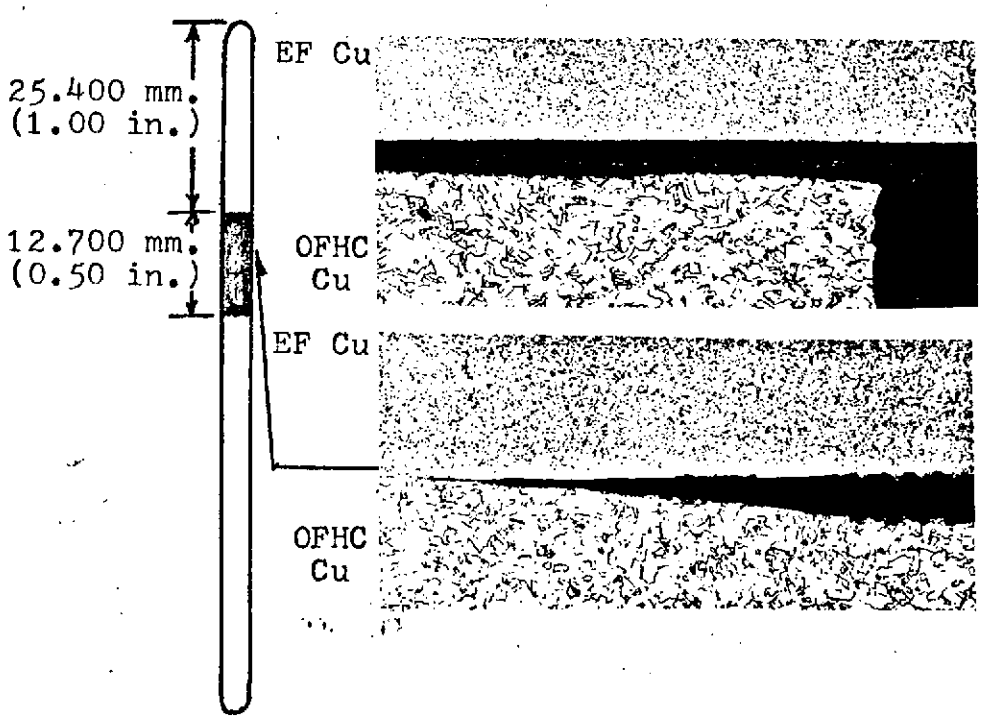
MATERIAL: Electroformed Copper

THICKNESS:	MM.	INCHES
①	1.2929	0.0509
②	1.2751	0.0502
③	1.2878	0.0507
④	1.2954	0.0510

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 1.10×10^7 N/m^2 (1,600 psi).

CENTER LAND DEFECT METALLOGRAPHIC ANALYSIS:

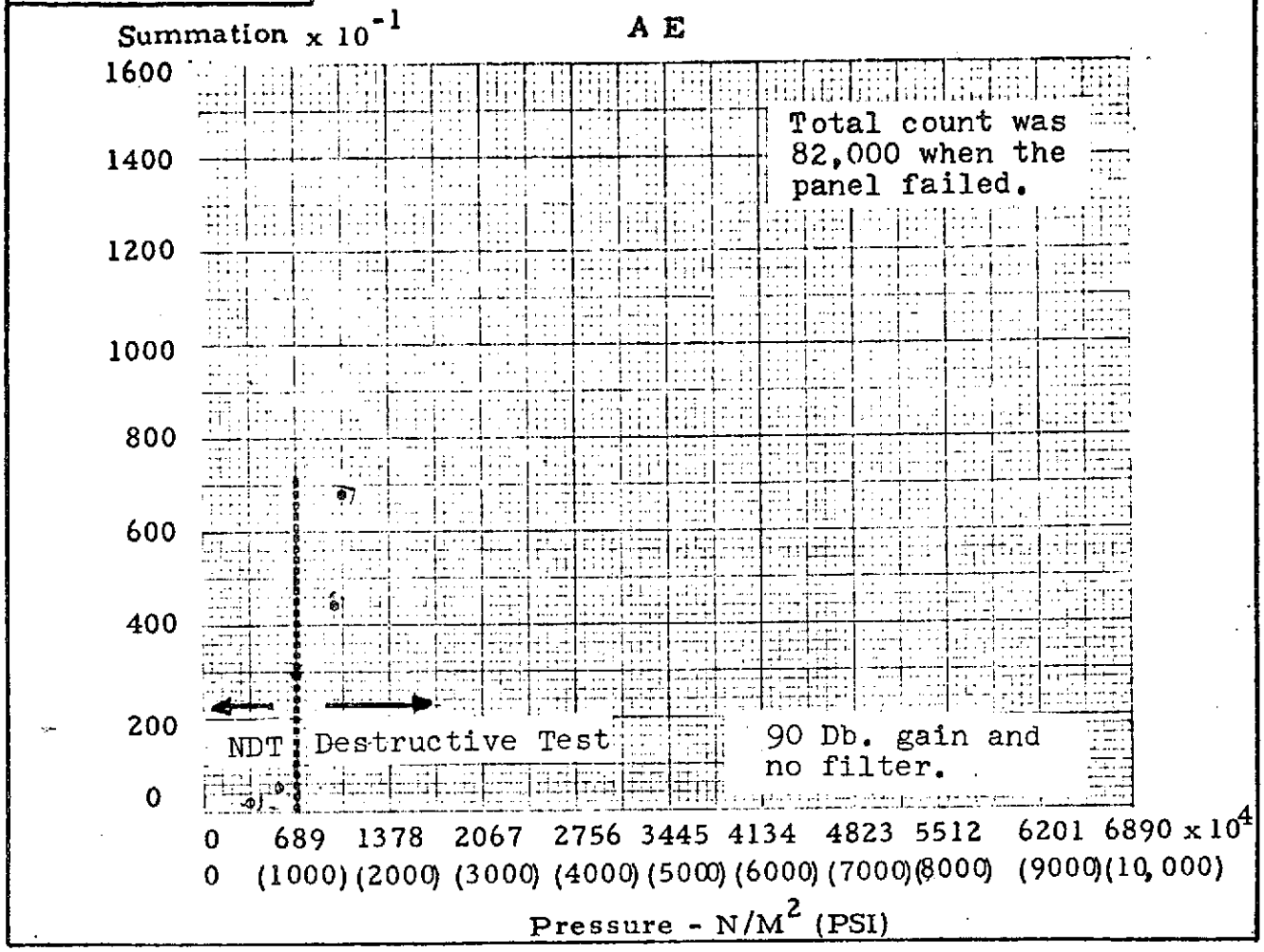


Section of an unplanned weak bond at the top manifold end of Land 3. Lack of metal disturbance indicates very weak bond. Magnification 50X.

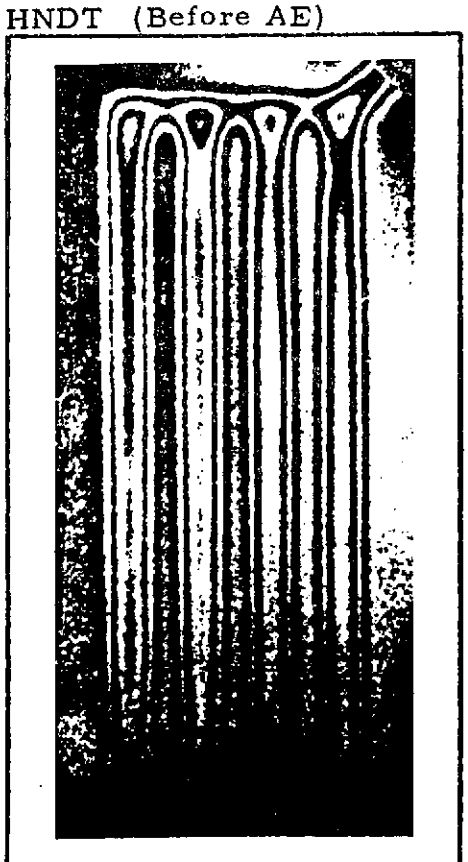
Section of the planned nonbond. Metal disturbance indicates some tack bonding had occurred. Magnification 50X.

FIGURE C-51

Panel No. C-27C



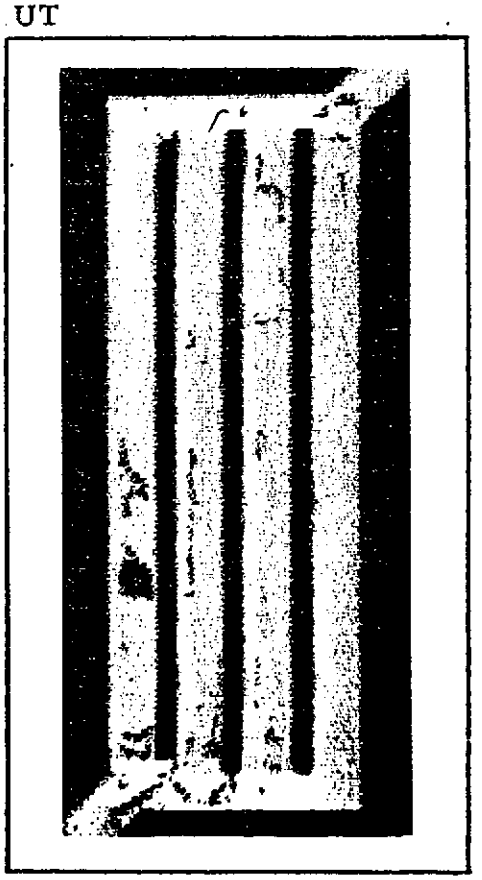
HNDT (Before AE)



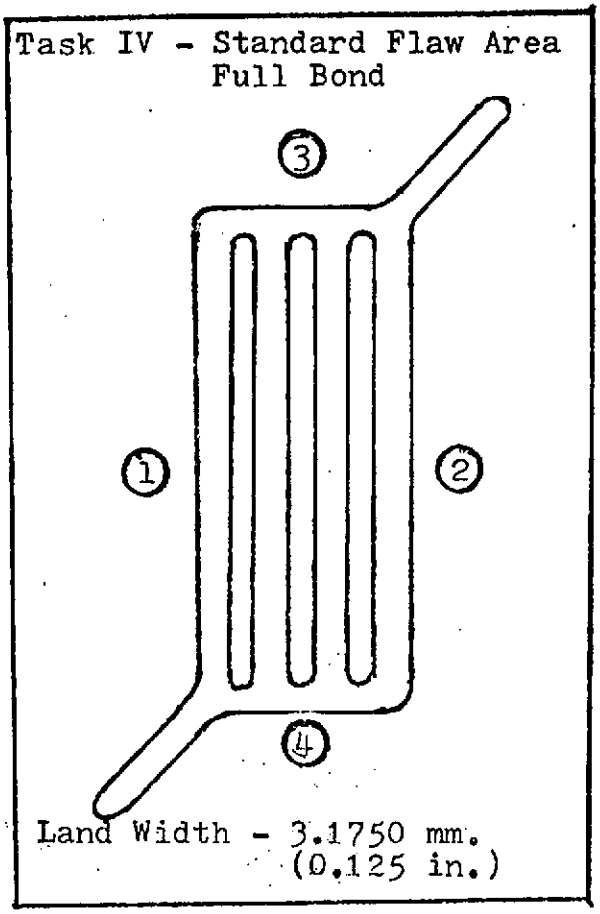
Press. 13.8 x 10^5 N/M^2
(200 PSI)

AE
FLAW LOCATOR
CENTER LAND

UT



BRAZED PANEL NO. B-04



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.4313	0.2532
②	6.4287	0.2531
③	6.4770	0.2550
④	6.3805	0.2512

COVERPLATE

MATERIAL: 304L Stainless Steel

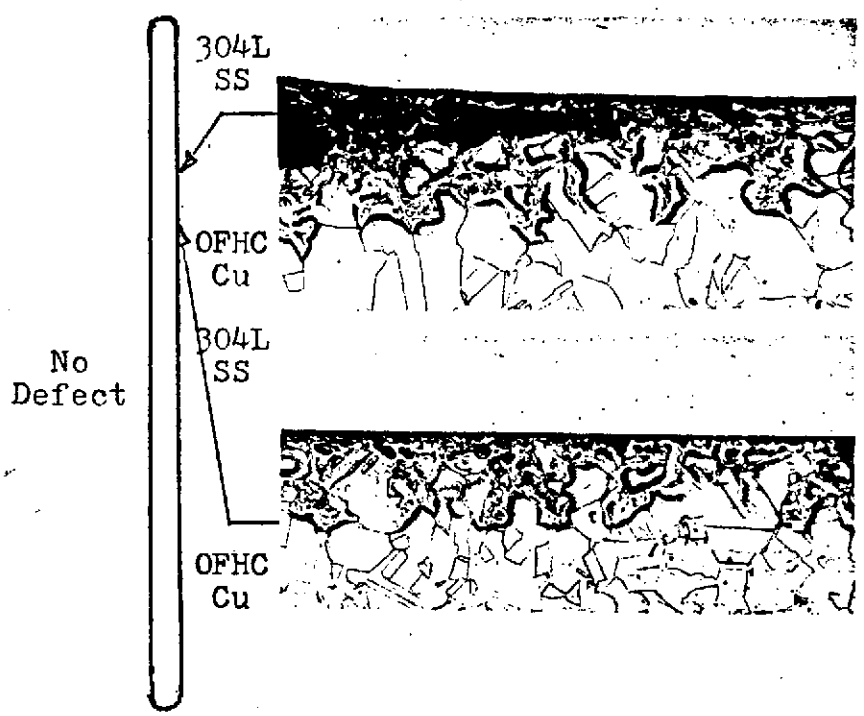
THICKNESS:	MM.	INCHES
①	1.2217	0.0481
②	1.2217	0.0481
③	1.2217	0.0481
④	1.2243	0.0482

PRESSURE REQUIRED TO FAIL BOND:

Bond failed at a pressure of 3.73×10^7 N/m^2 (5,400 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

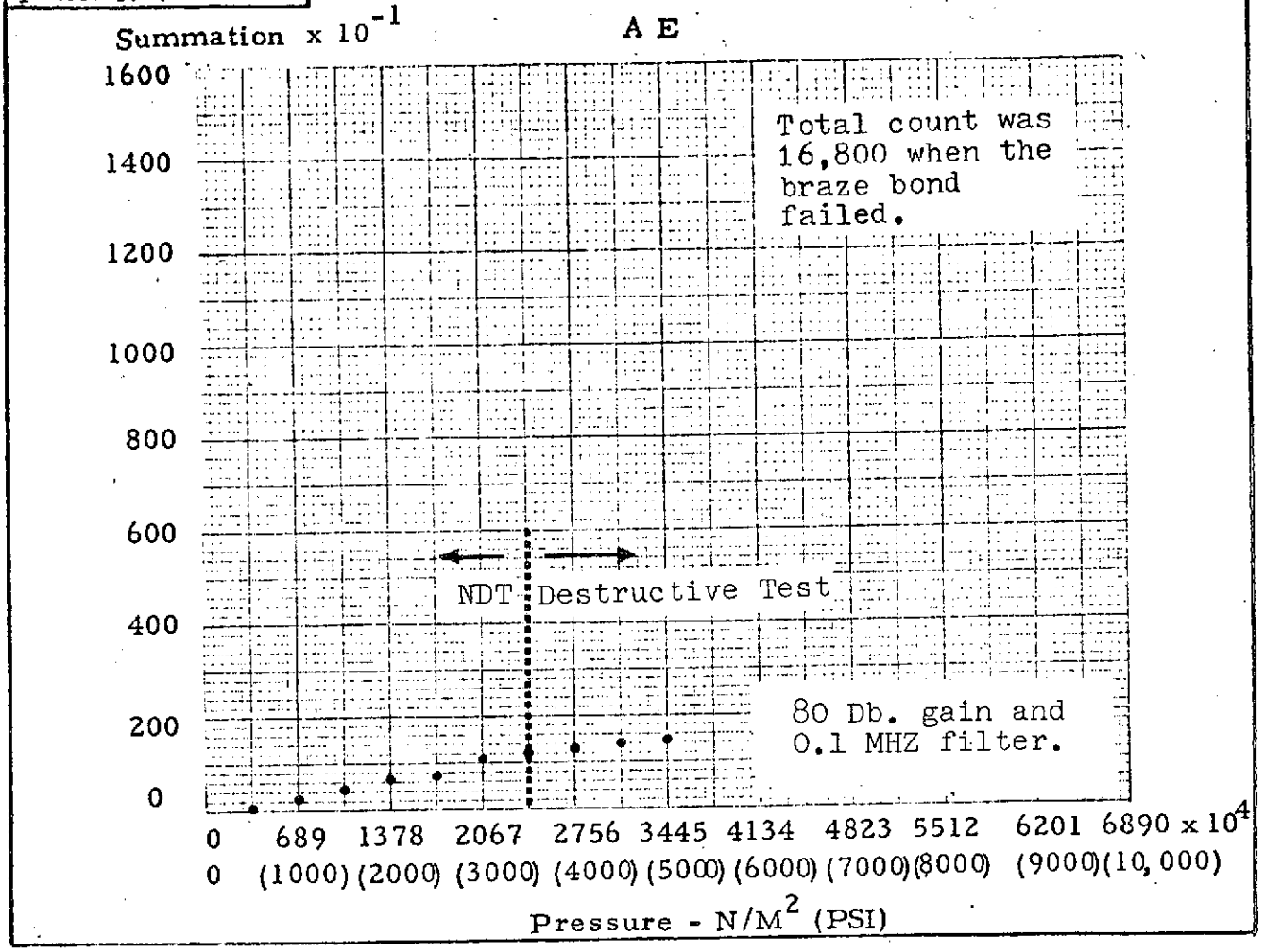


Planned full bond showing area of braze failure from destructive test. Magnification 50X.

Area of planned full bond next to bond failure after destructive test. Magnification 50X.

FIGURE C-52

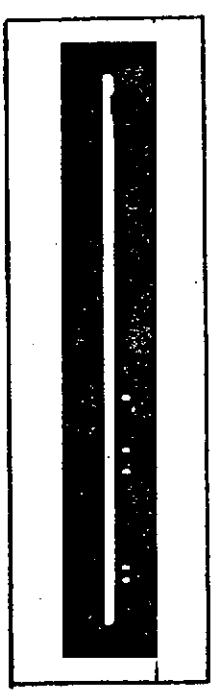
Panel No. B-4



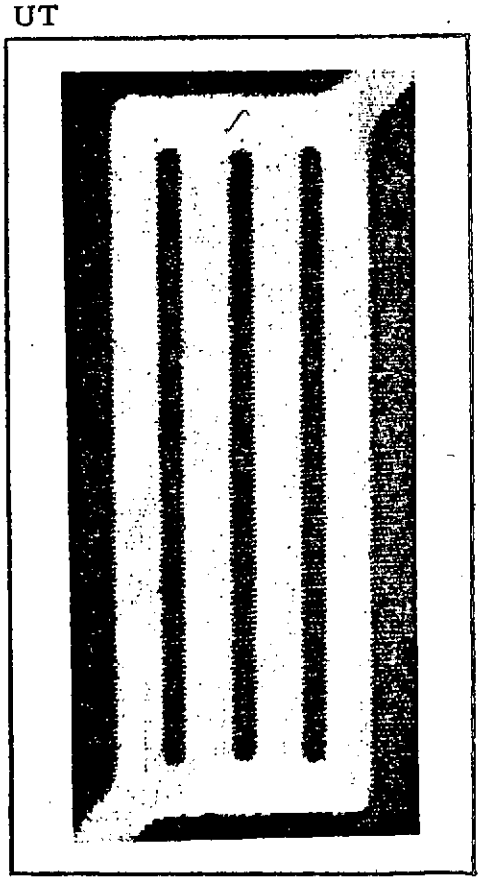
HNDT (Before AE)

Press. - 13.8 x 10^5 N/M^2
(200 PSI)

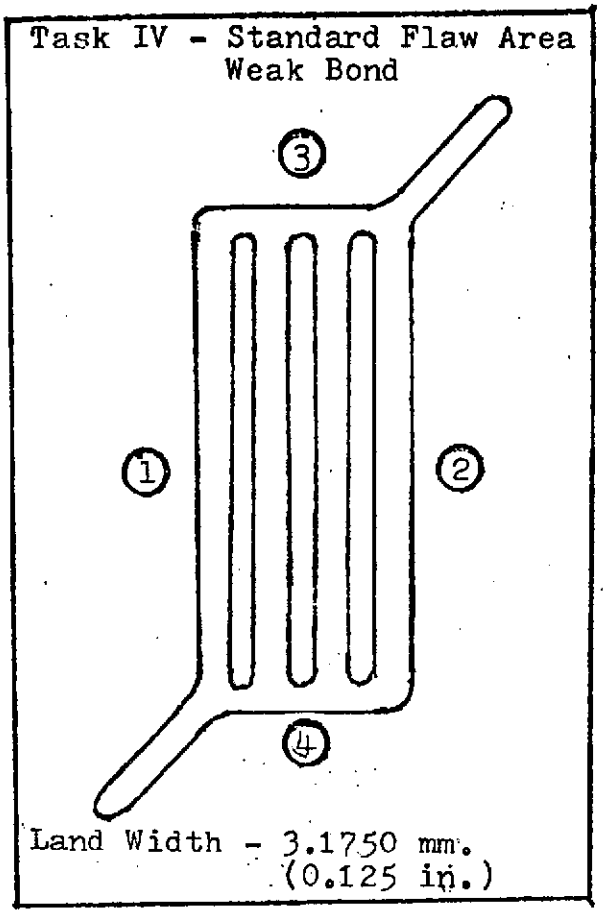
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-18



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.6827	0.2631
②	6.6091	0.2602
③	6.6599	0.2622
④	6.7234	0.2647

COVERPLATE

MATERIAL: 304L Stainless Steel

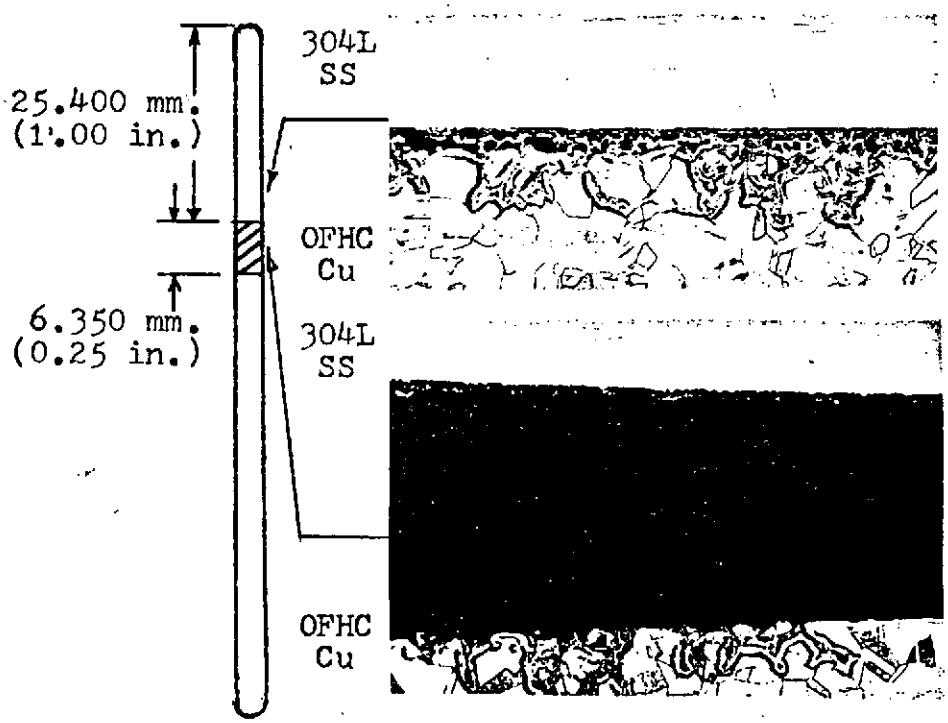
THICKNESS:	MM.	INCHES
①	1.2217	0.0481
②	1.2243	0.0482
③	1.2243	0.0482
④	1.2243	0.0482

PRESSURE REQUIRED TO FAIL BOND:

Braze failed at a pressure of $2.90 \times 10^7 N/m^2$ (4,200 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

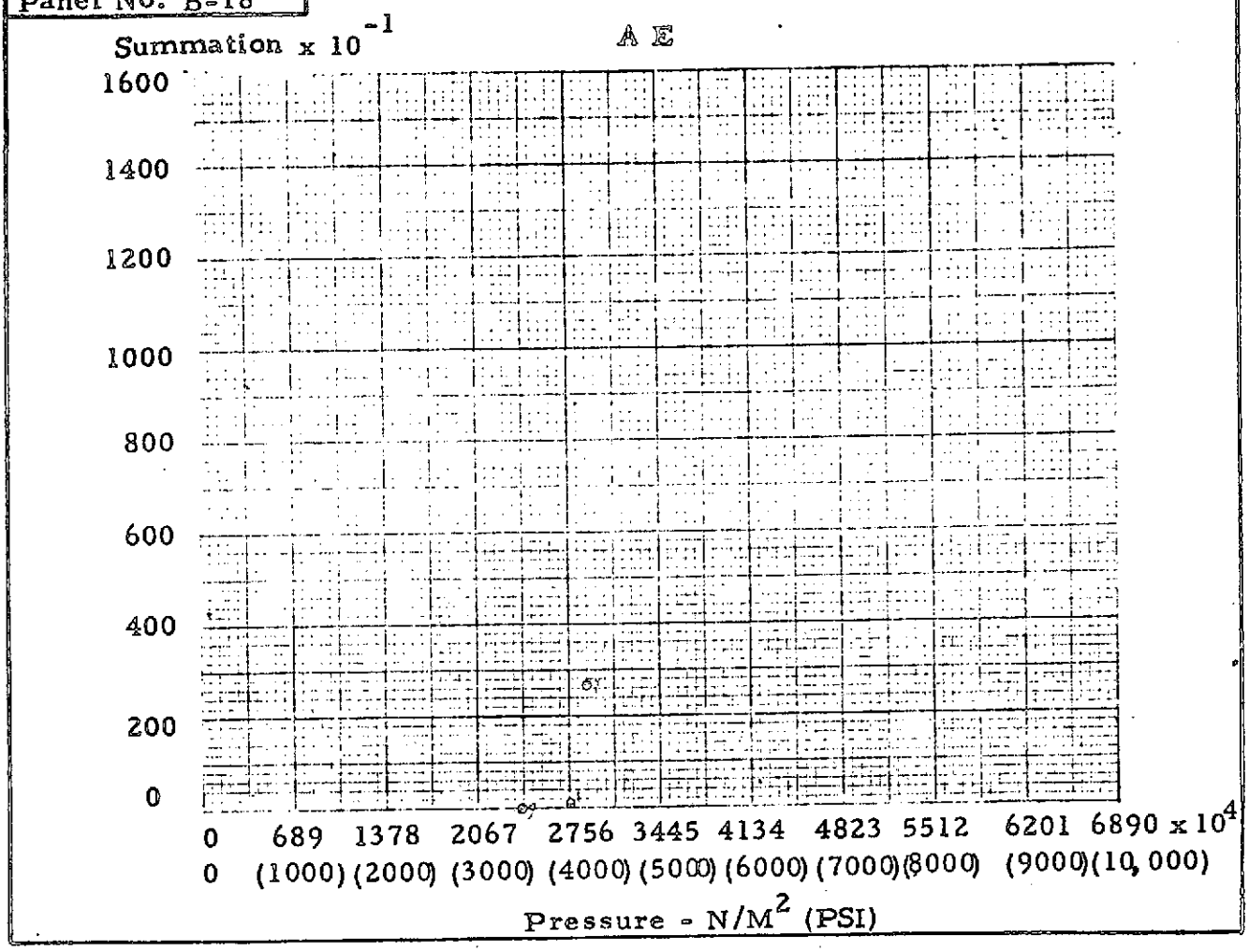


Full braze bond near the planned weak bond. Voids in braze indicate some metal failure in destructive test. Magnification 50X.

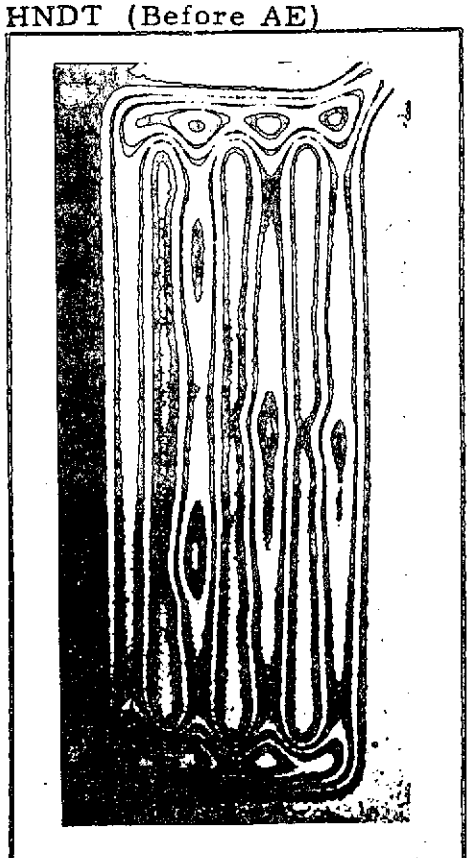
Complete bondline separation occurred in the planned weak bond. Braze layer appears to be "starved". Magnification 50X.

FIGURE C-53

Panel No. B-18



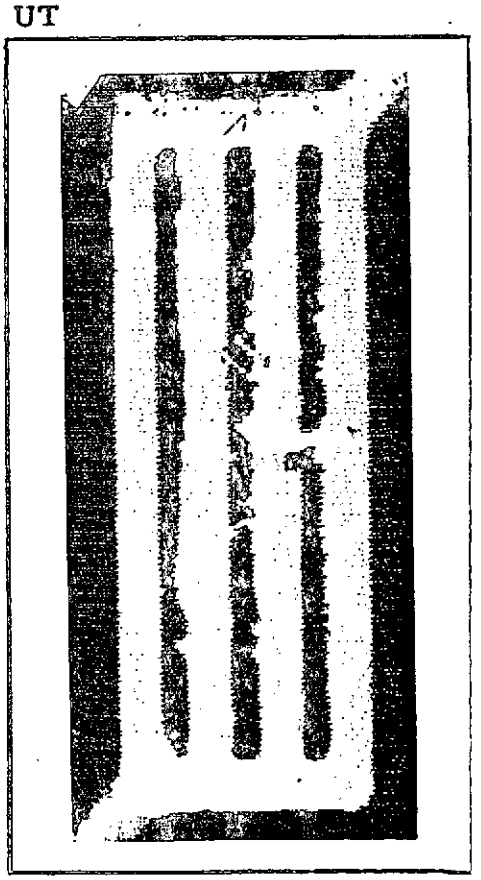
HNDT (Before AE)



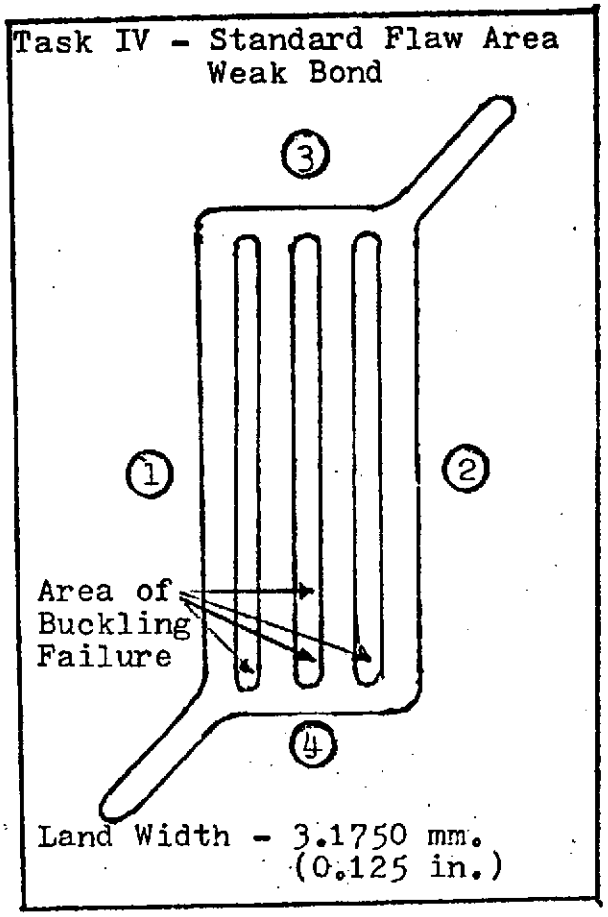
Press. 13.8 x 10^5 N/M^2
(200 PSI)

AE
FLAW LOCATOR
CENTER LAND

UT



BRAZED PANEL NO. B-16



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.6904	0.2634
②	6.7031	0.2639
③	6.7005	0.2638
④	6.6827	0.2631

COVERPLATE

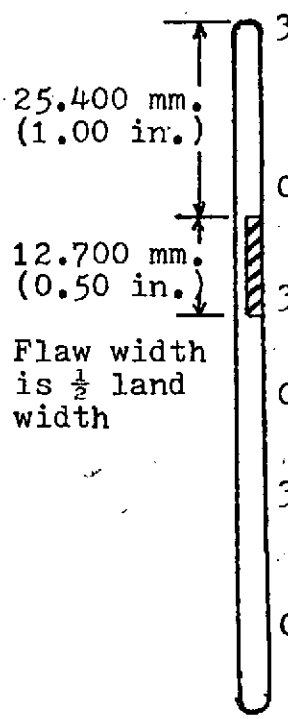
MATERIAL: 304L Stainless Steel

THICKNESS:	MM.	INCHES
①	1.2243	0.0482
②	1.2243	0.0482
③	1.2243	0.0482
④	1.2217	0.0481

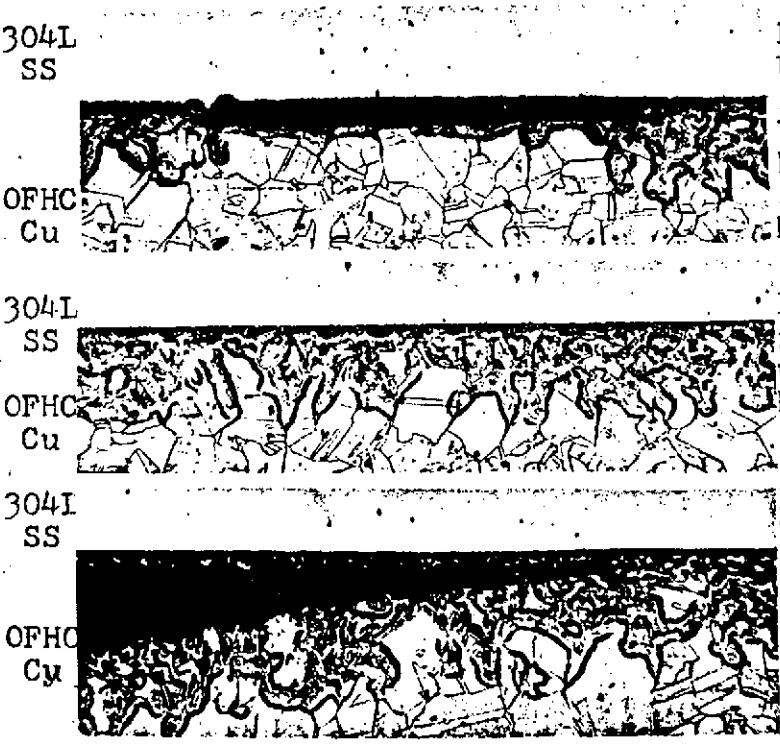
PRESSURE REQUIRED TO FAIL BOND:

Braze failed at a pressure of 2.83×10^7 N/m^2 (4,100 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:



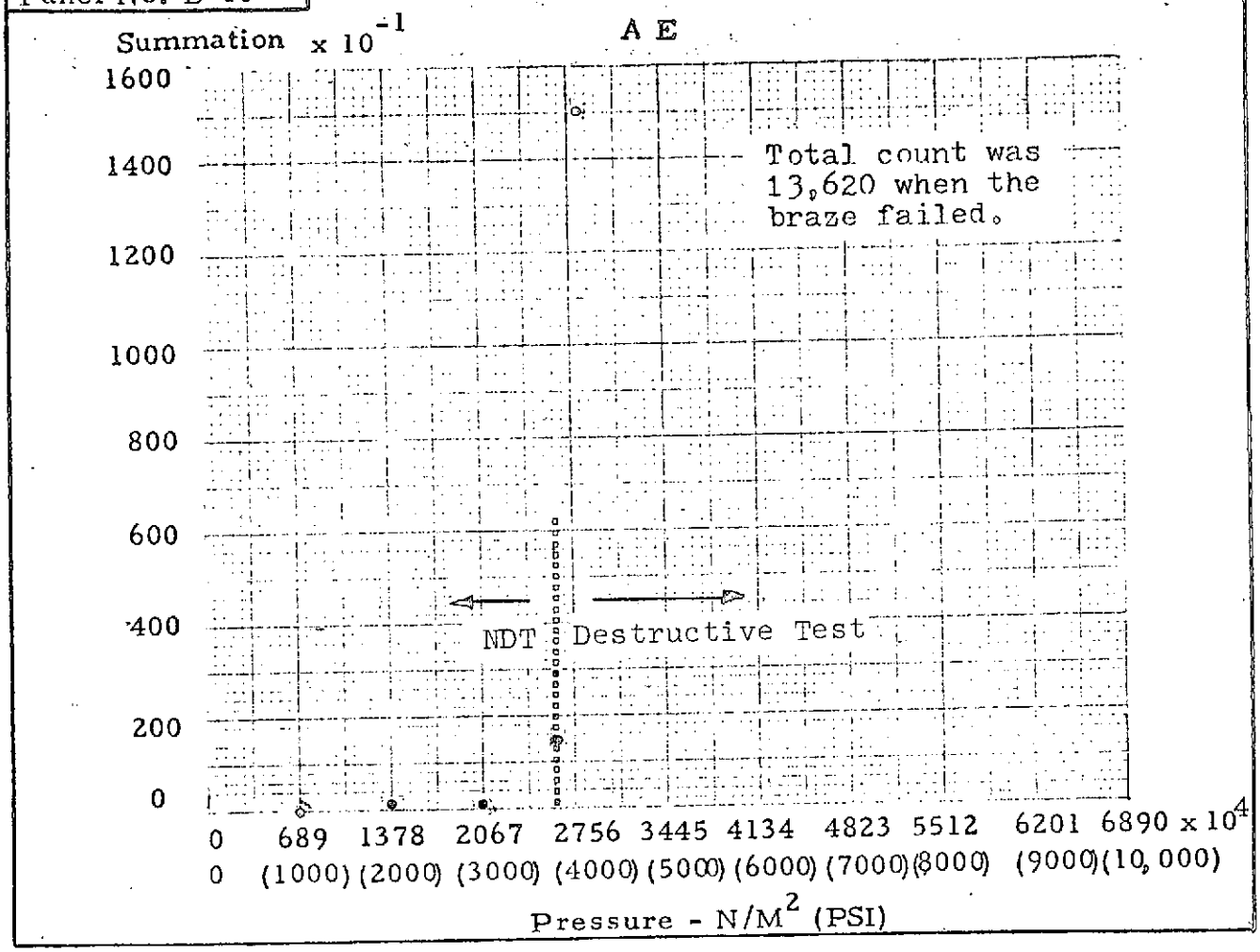
Planned weak bond with intermittent braze joints. Note slight separation. Magnification 50X.

Full bond area next to planne weak bond. Magnification 50X

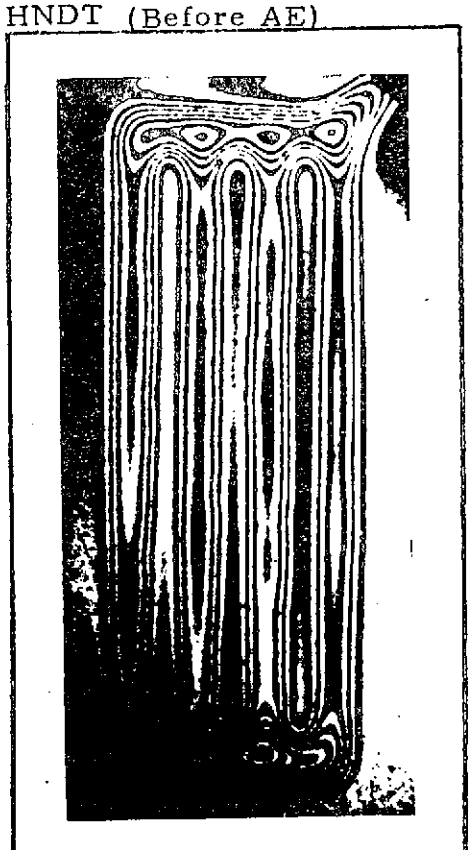
Failed full bond after the destructive test. Magnification 50X.

FIGURE C-54

Panel No. B-16

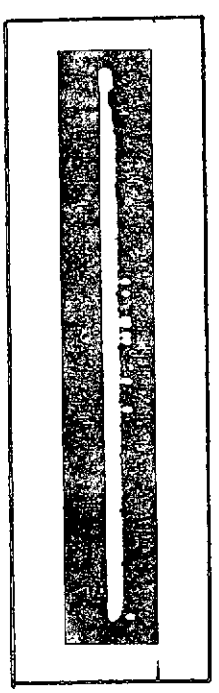


HNDT (Before AE)

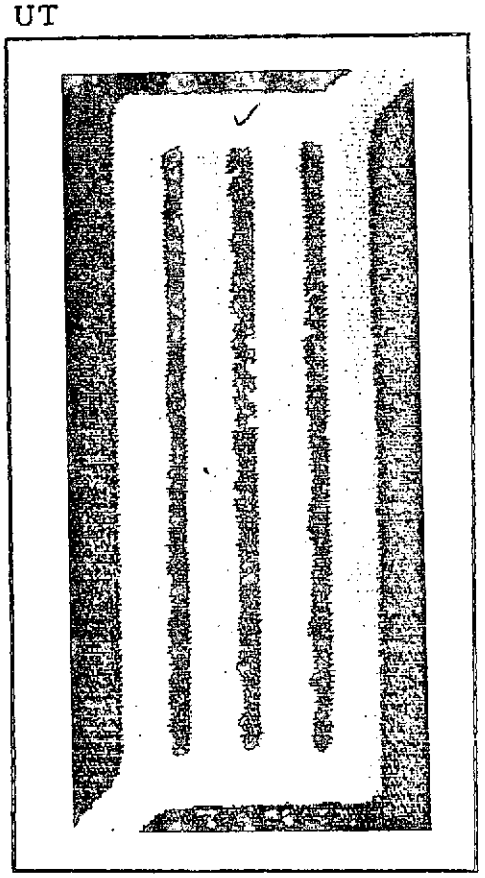


Press. 20.7 x 10^5 N/M^2
(300 PSI)

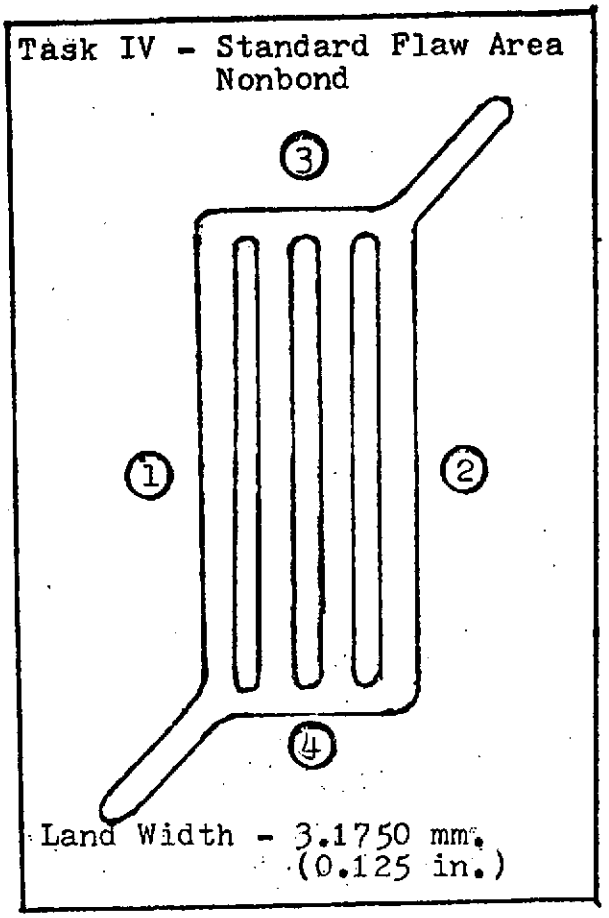
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-08



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
1	6.6675	0.2625
2	6.6700	0.2626
3	6.6599	0.2622
4	6.6396	0.2614

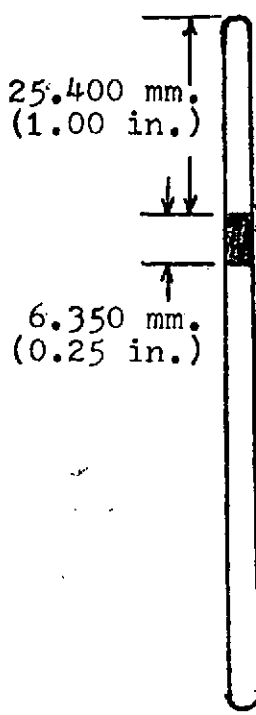
COVERPLATE

MATERIAL: 304L Stainless Steel

THICKNESS:	MM.	INCHES
1	1.2268	0.0483
2	1.2268	0.0483
3	1.2268	0.0483
4	1.2243	0.0482

PRESSURE REQUIRED TO FAIL BOND: Panel showed visible failure at a pressure of 3.45×10^7 N/m^2 (5,000 psi). Nonbond separation may have occurred at a lower value.

CENTER LAND DEFECT



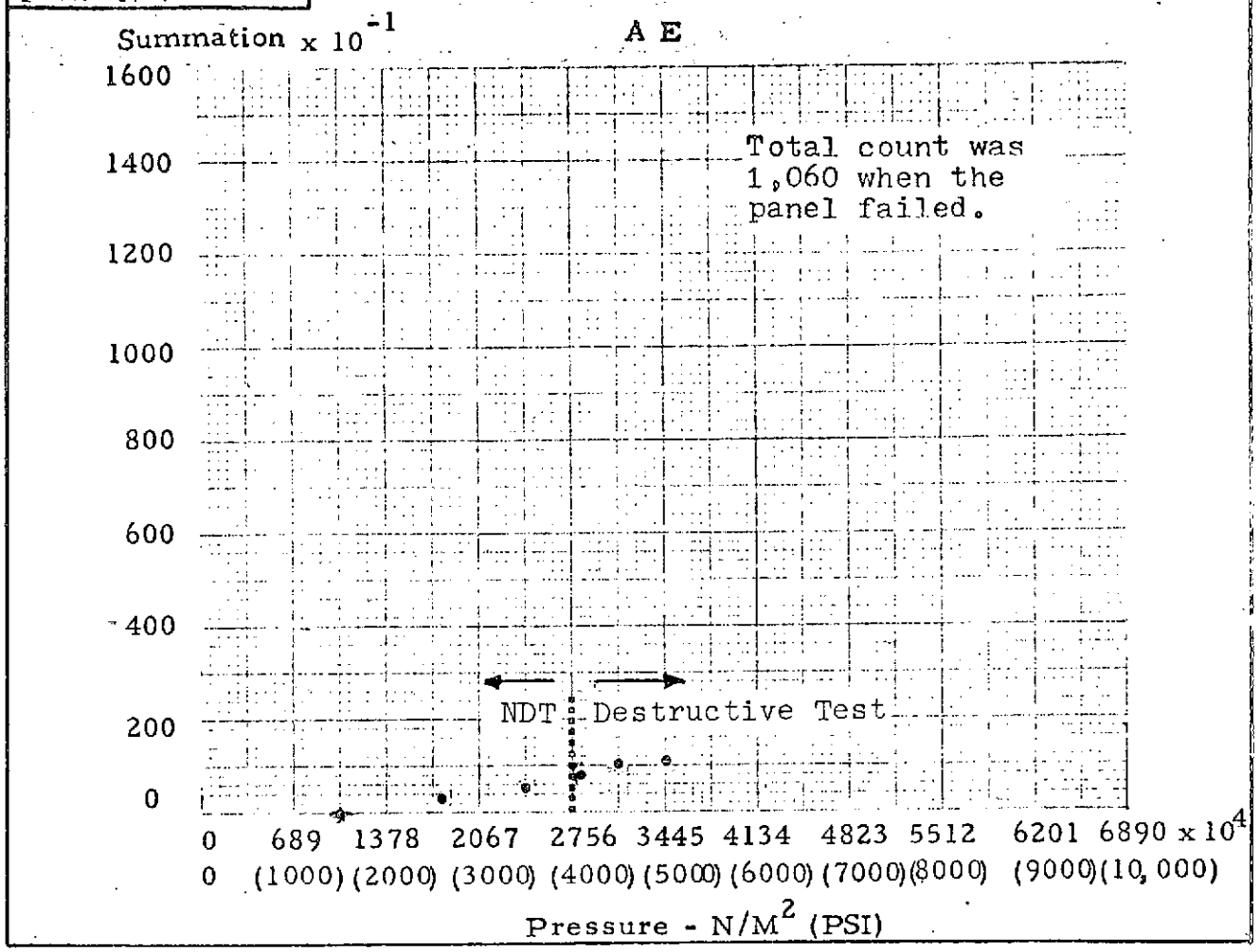
METALLOGRAPHIC ANALYSIS:

Planned nonbond area showing some braze wetting of the OFHC Copper but no wetting of the 304L SS. Magnification 50X.

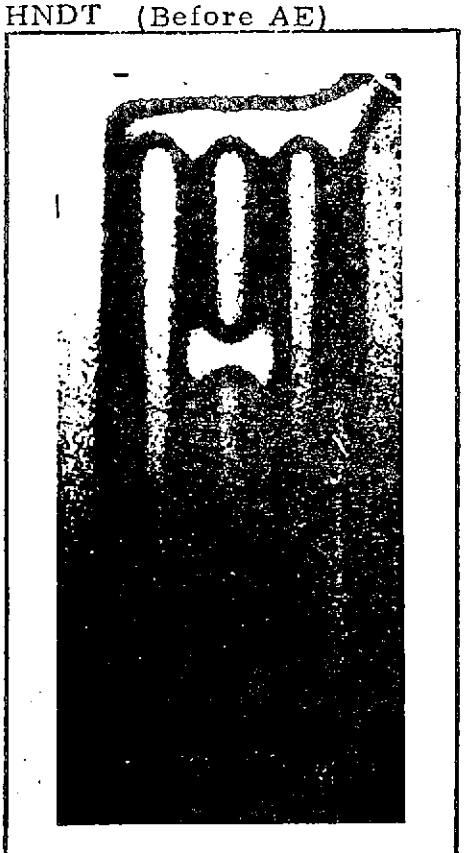
Section of the full bond next to the planned nonbond. No failure occurred. Magnification 50X.

FIGURE C-55

Panel No. B-8

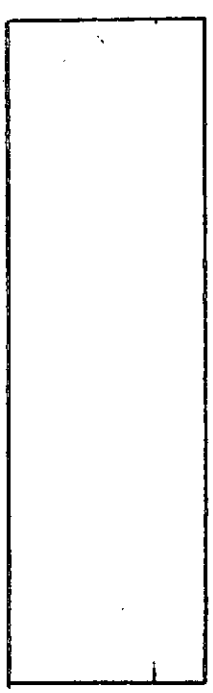


HNDT (Before AE)

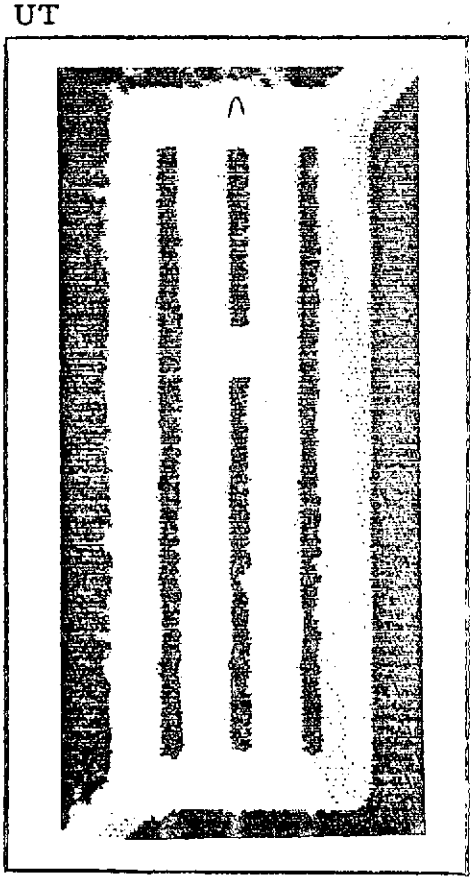


Press. 34.5 x 10^5 N/M^2
(500 PSI)

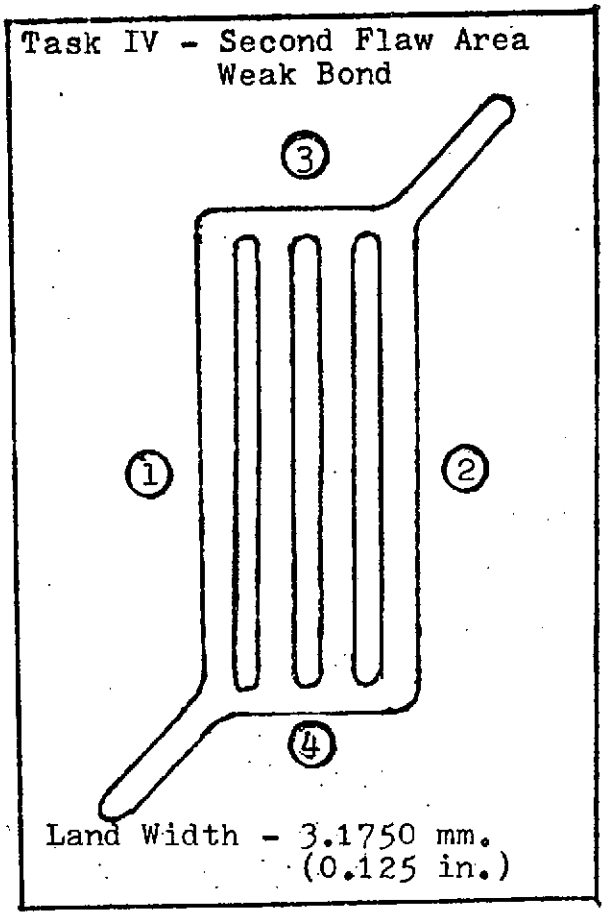
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-20



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.3551	0.2502
②	6.4059	0.2522
③	6.4414	0.2536
④	6.3525	0.2501

COVERPLATE

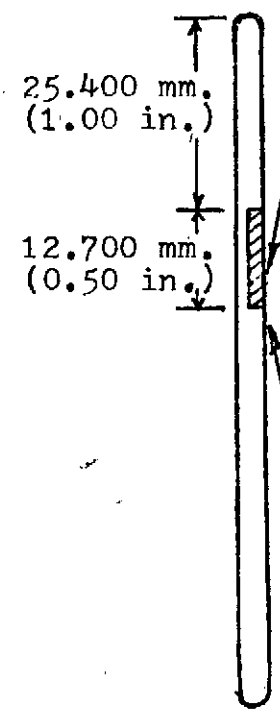
MATERIAL: 304L Stainless Steel

THICKNESS:	MM.	INCHES
①	1.2217	0.0481
②	1.2217	0.0481
③	1.2243	0.0482
④	1.2217	0.0481

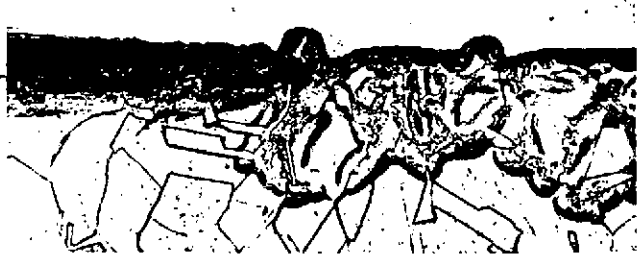
PRESSURE REQUIRED TO FAIL BOND:

Braze failed at a pressure of 3.24×10^7 N/m^2 (4,700 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

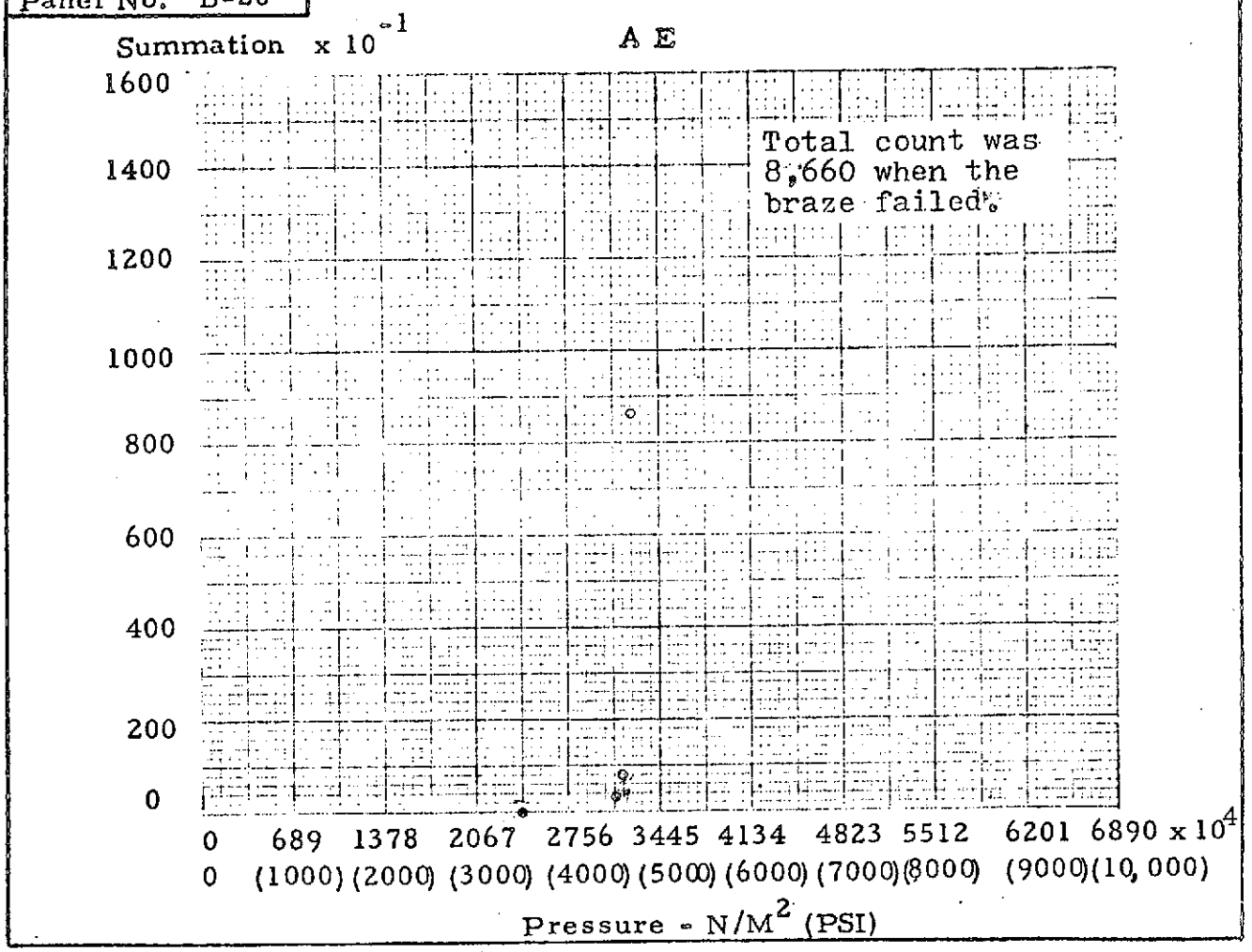


Section from planned weak bond showing end of defect. Slight separation occurred. Magnification 50X.

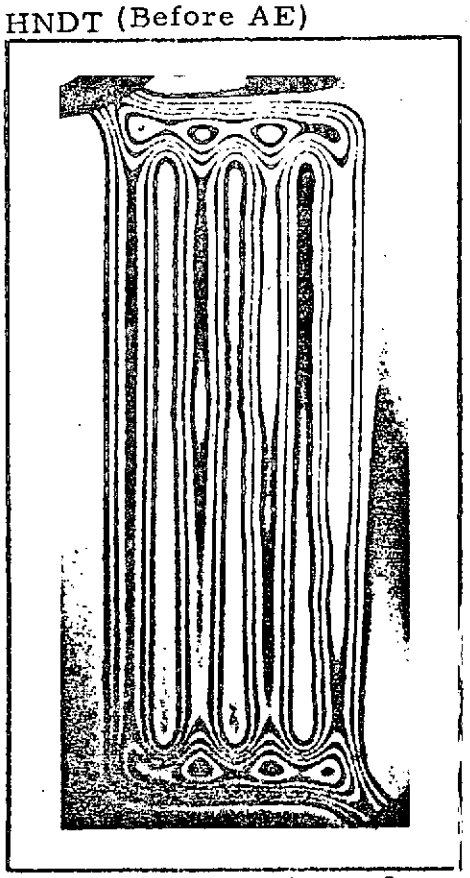
Full braze bond area next to the planned weak bond. In destructive test, failure occurred. Magnification 50X.

FIGURE C-56

Panel No. B-20

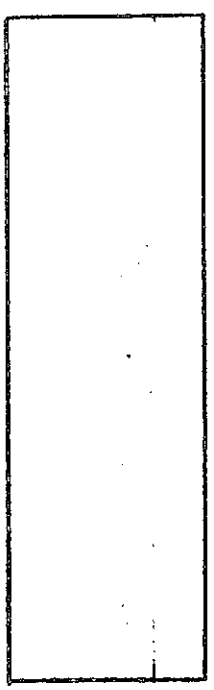


HNDT (Before AE)

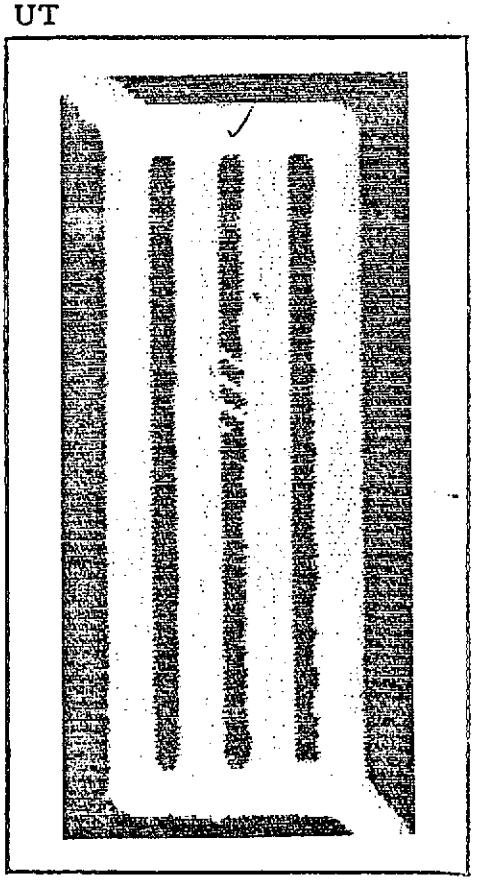


Press. 20.7 x 10^5 N/M^2
(300 PSI)

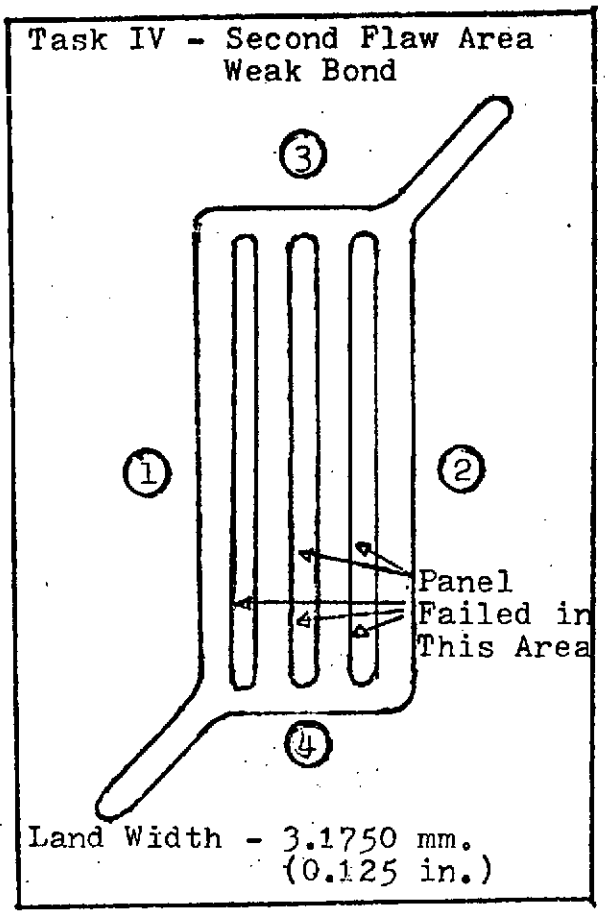
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-17



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.6624	0.2623
②	6.6523	0.2619
③	6.6777	0.2629
④	6.6015	0.2599

COVERPLATE

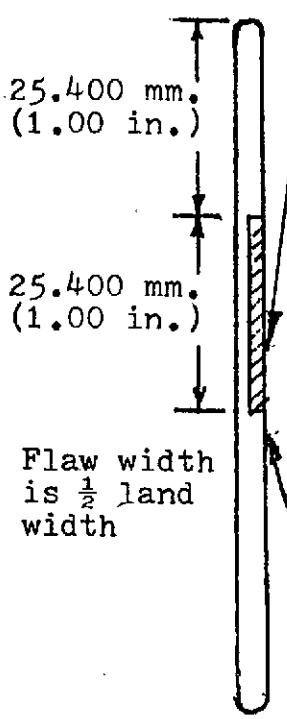
MATERIAL: 304L Stainless Steel

THICKNESS:	MM.	INCHES
①	1.2243	0.0482
②	1.2243	0.0482
③	1.2268	0.0483
④	1.2243	0.0482

PRESSURE REQUIRED TO FAIL BOND:

Braze failed at a pressure of 2.83×10^7 N/m^2 (4,100 psi).

CENTER LAND DEFECT



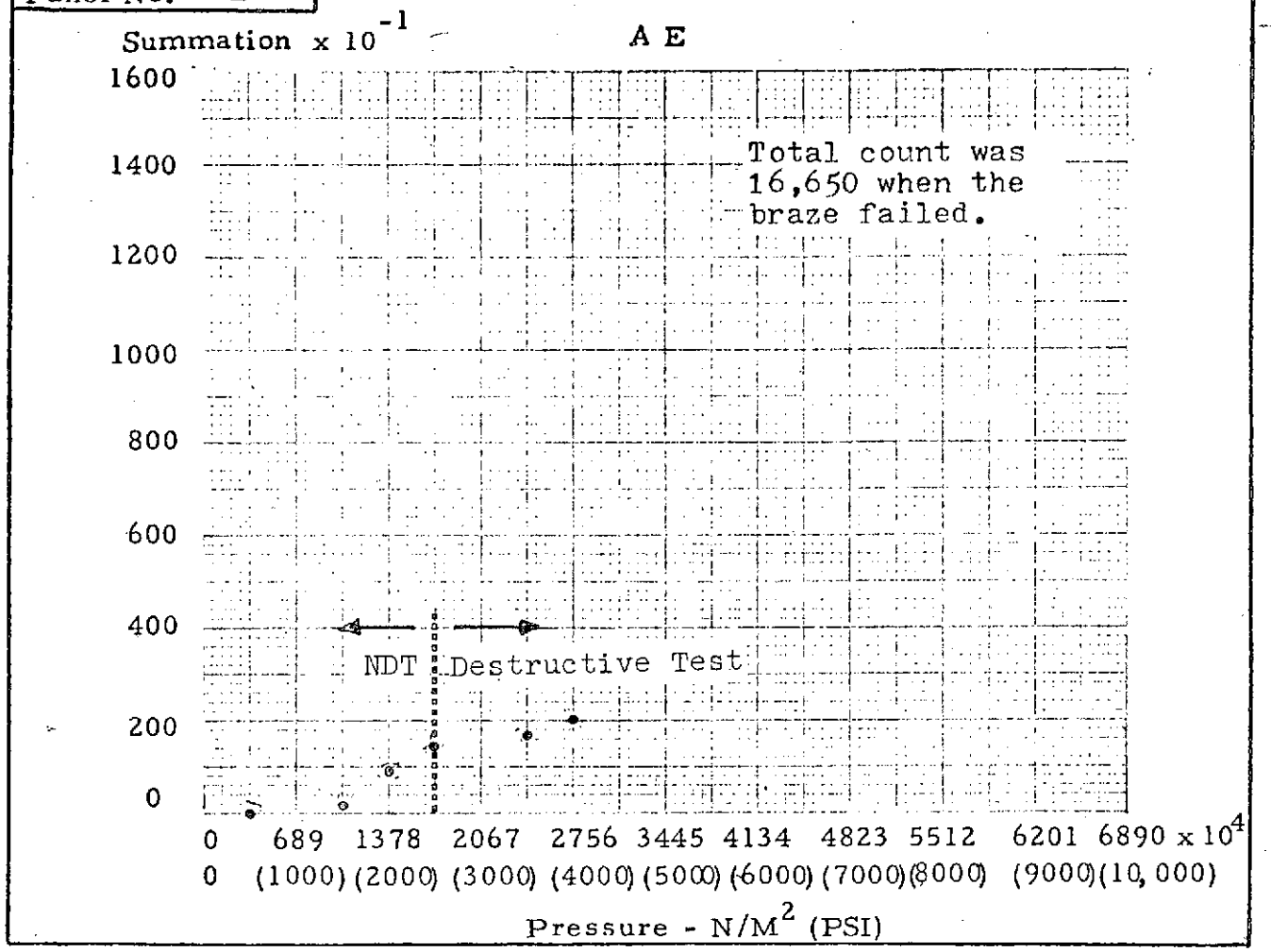
METALLOGRAPHIC ANALYSIS:

Section from planned weak bond showing intermittent braze bonding to produce the required defect, but no separation is evident from destructive test. Magnification 50X.

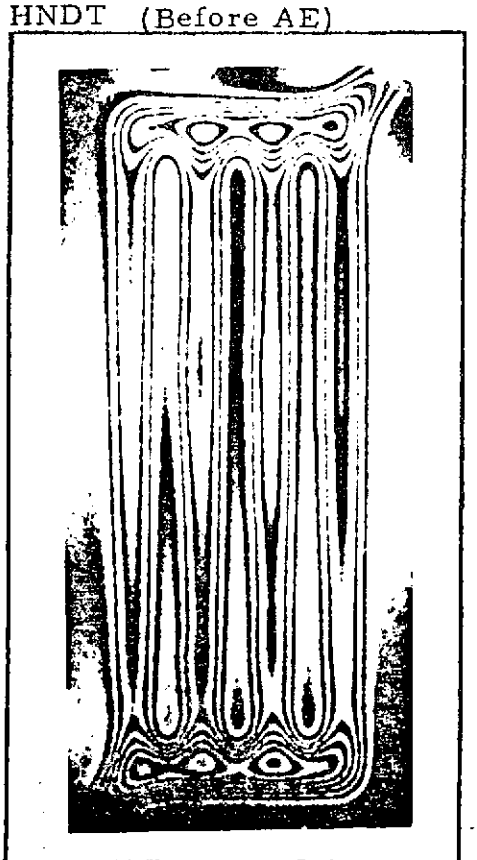
Section from planned full bond area next to the planned weak bond. It was noted that the expected braze wetting occurred. Although the bond held in destructive test, some rupture is evident. Magnification 50X.

FIGURE C-57

Panel No. B-17



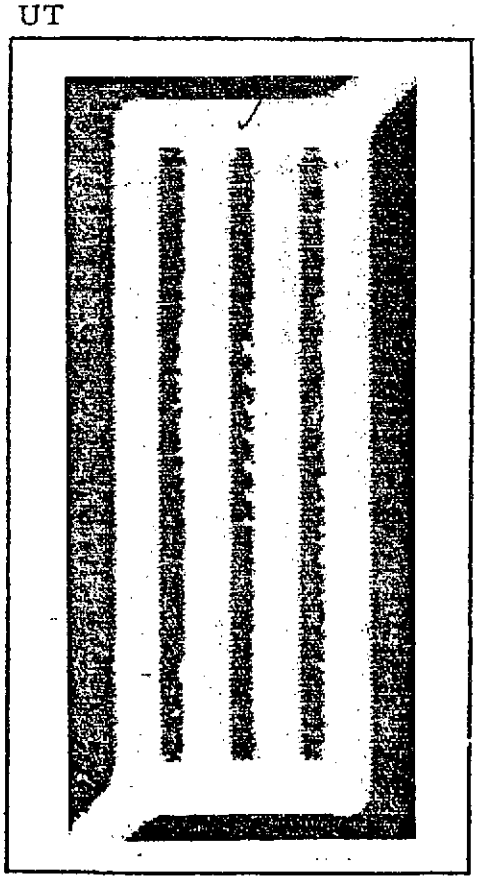
HNDT (Before AE)



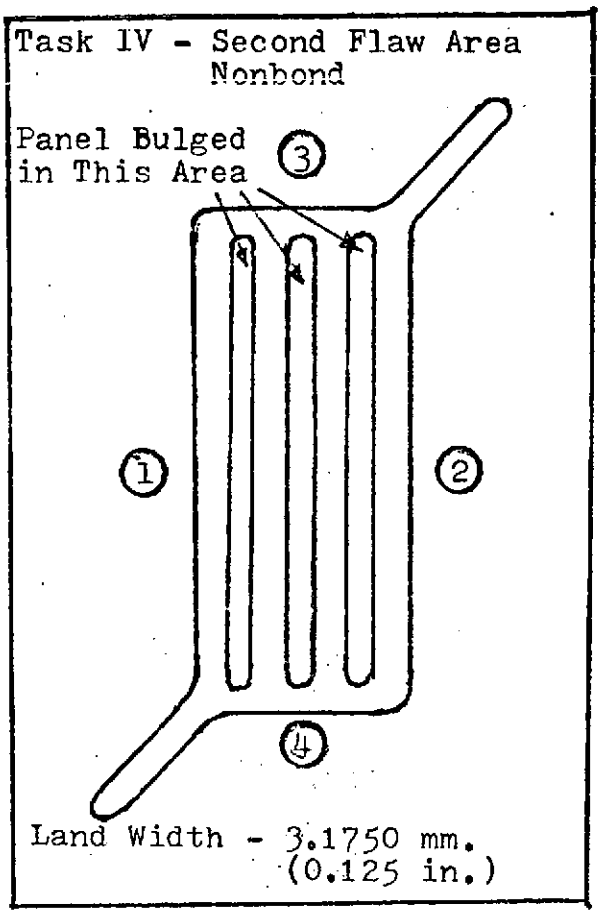
Press. 20.7 x 10^5 N/M^2
(300 PSI)

AE
FLAW LOCATOR
CENTER LAND

UT



BRAZED PANEL NO. B-09



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.6116	0.2603
②	6.5481	0.2578
③	6.5430	0.2576
④	6.6015	0.2599

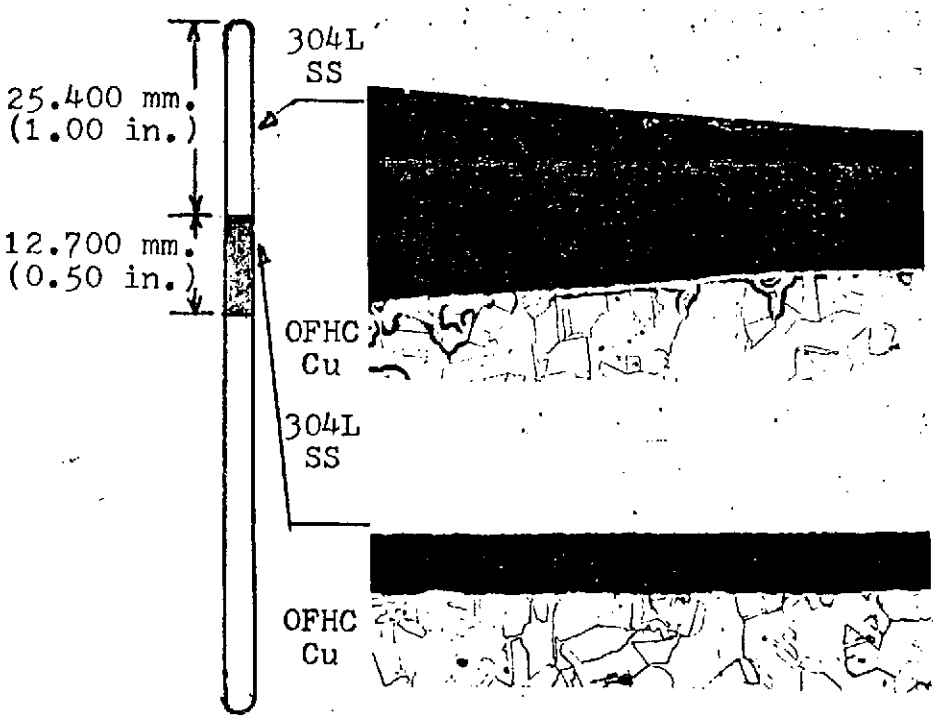
COVERPLATE

MATERIAL: 304L Stainless Steel

THICKNESS:	MM.	INCHES
①	1.2243	0.0482
②	1.2243	0.0482
③	1.2268	0.0483
④	1.2243	0.0482

PRESSURE REQUIRED TO FAIL BOND:
Defect separation was not visible until adjacent braze bond failed at 3.38×10^7 N/m^2 (4,900 psi).

CENTER LAND DEFECT



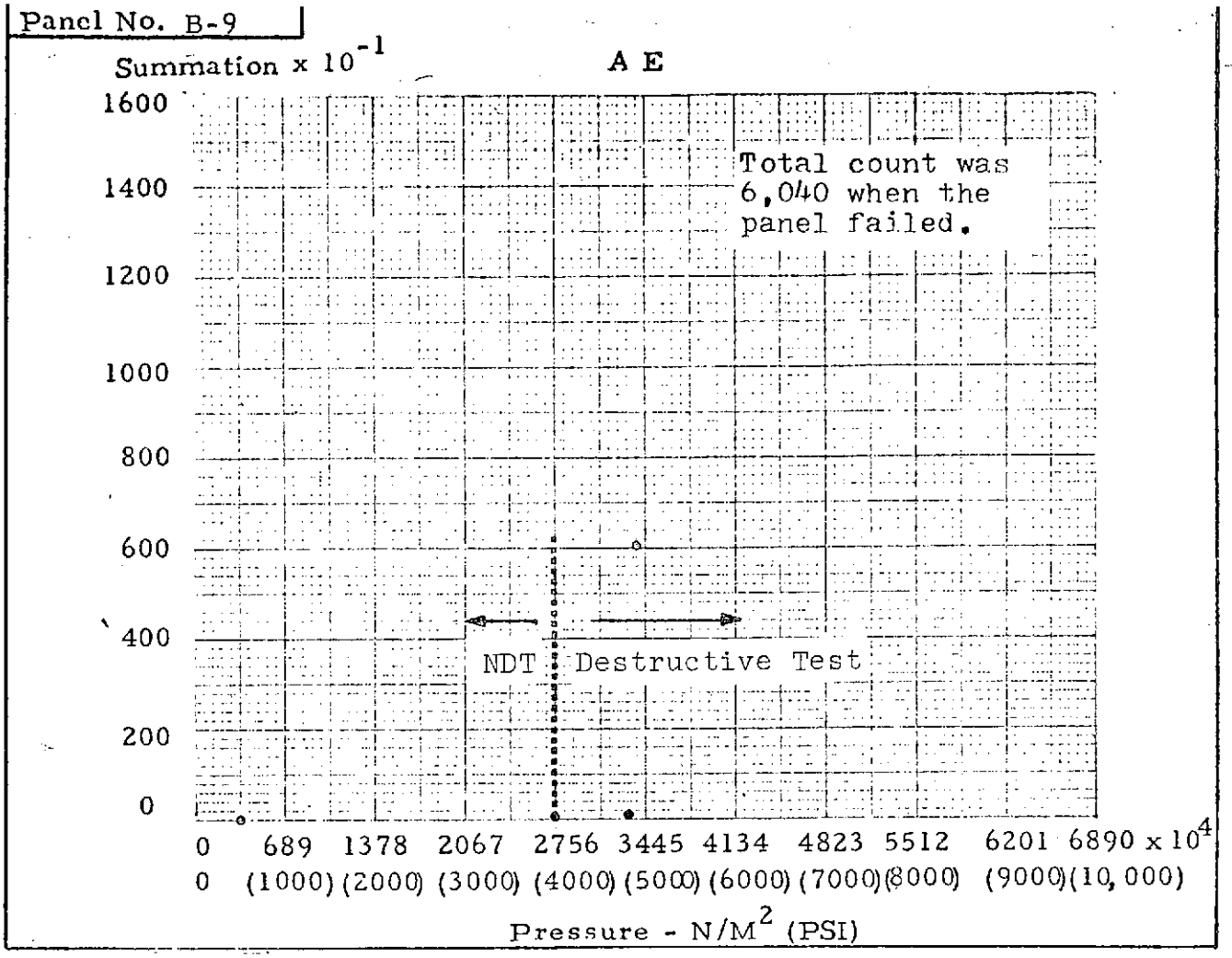
METALLOGRAPHIC ANALYSIS:

Full bond area showing failure through braze alloy. Braze layer appears thin. Magnification 50X.

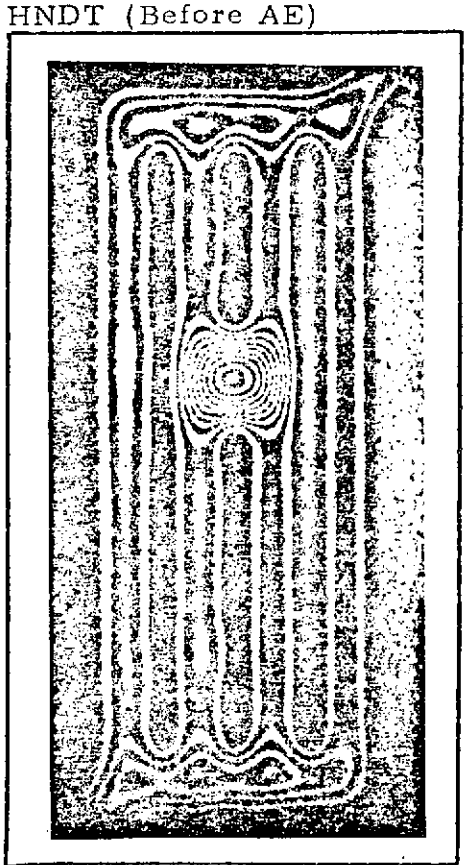
Section from the planned nonbond defect showing coverplate separation. Magnification 50X.

FIGURE C-58

Panel No. B-9

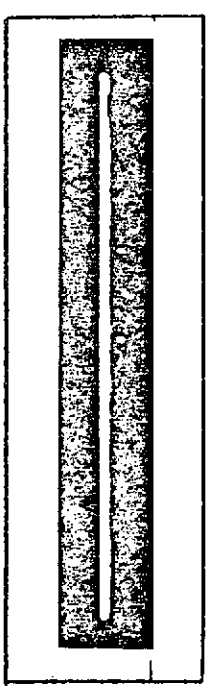


HNDT (Before AE)

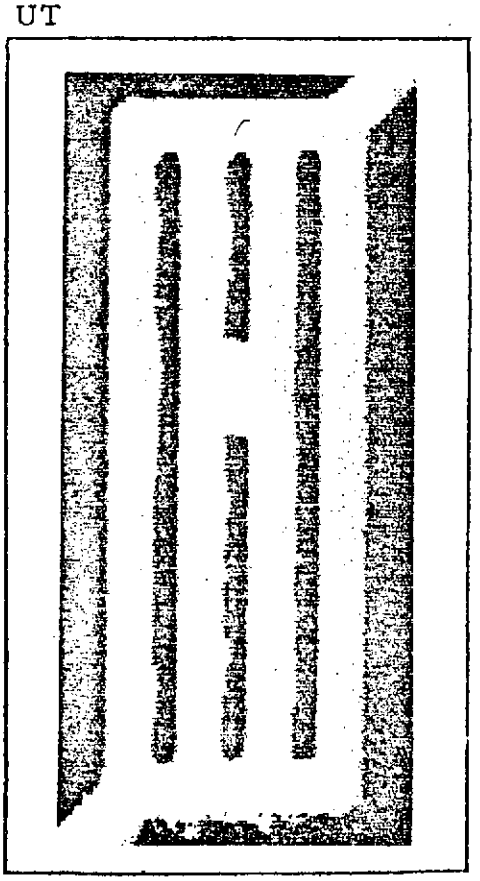


Press. - 10.35×10^5 N/M^2
(150 PSI)

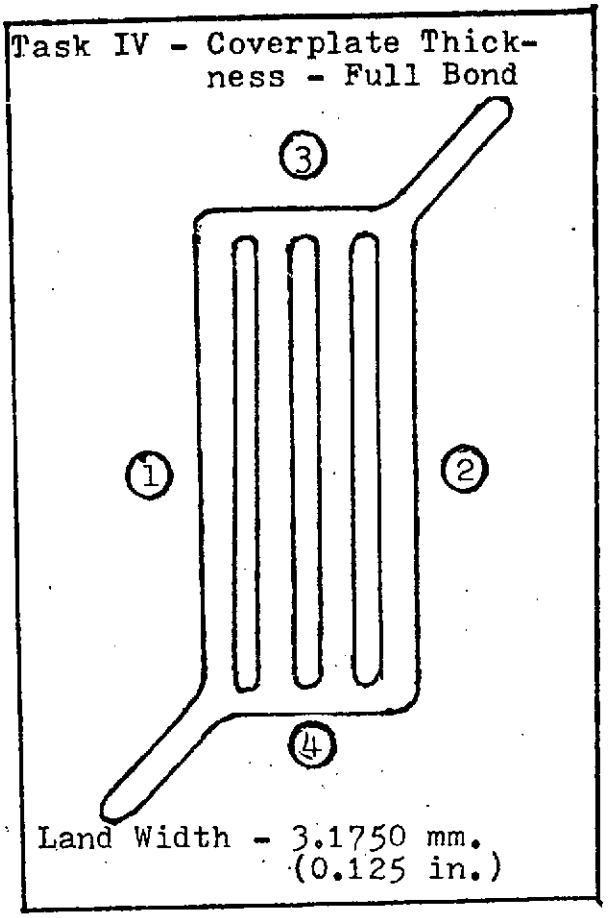
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-06



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.5126	0.2564
②	6.4770	0.2550
③	6.5151	0.2565
④	6.4338	0.2533

COVERPLATE

MATERIAL: 347 Stainless Steel

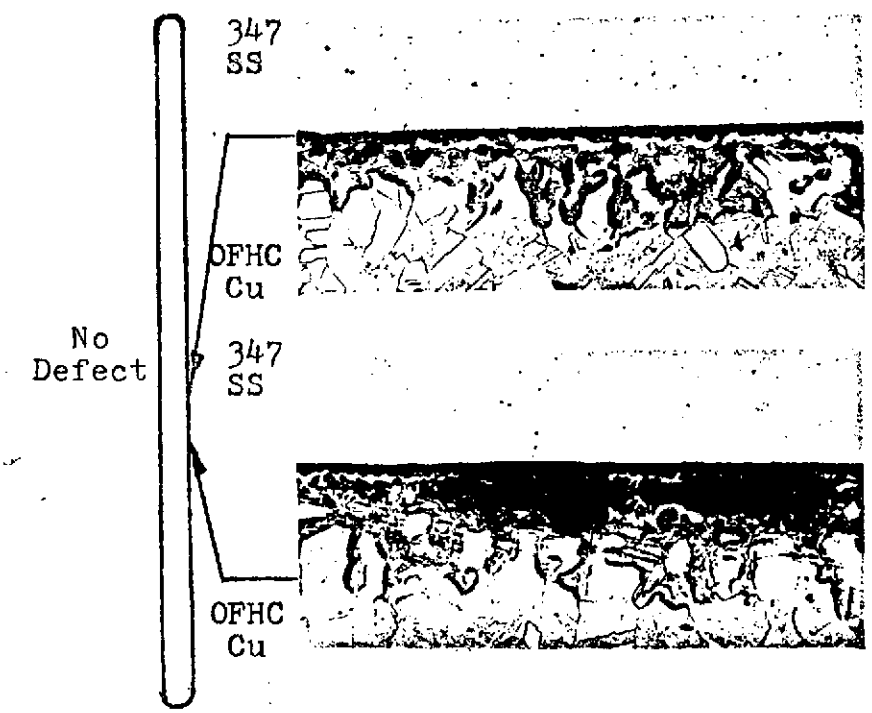
THICKNESS:	MM.	INCHES
①	2.3419	0.0922
②	2.3419	0.0922
③	2.3444	0.0923
④	2.3419	0.0922

PRESSURE REQUIRED TO FAIL BOND:

Panel failed at a pressure of 5.11×10^7 N/m^2 (7,400 psi).

CENTER LAND DEFECT

METALLOGRAPHIC ANALYSIS:

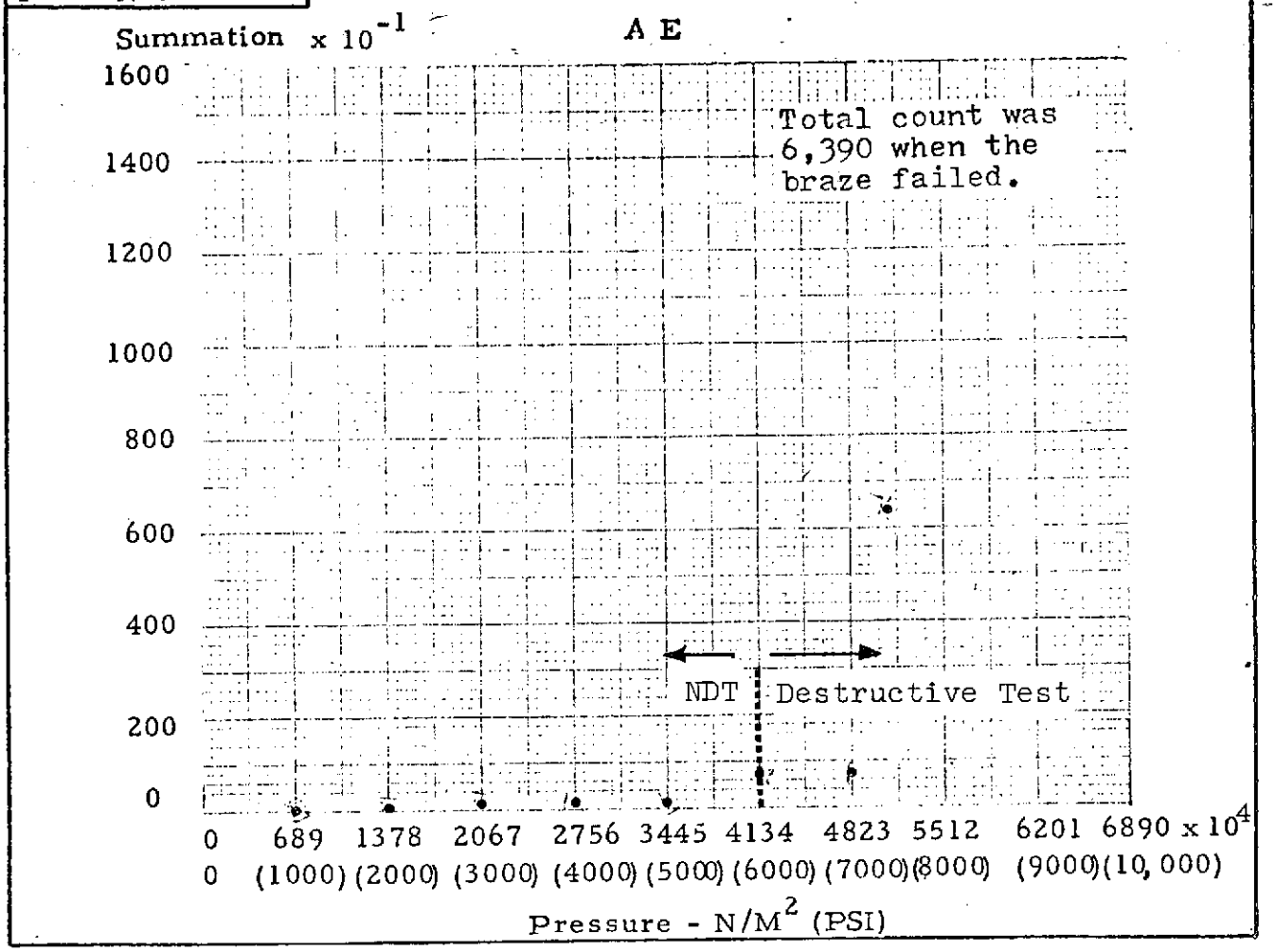


Section of planned full bond from an area of no failure. Magnification 50X.

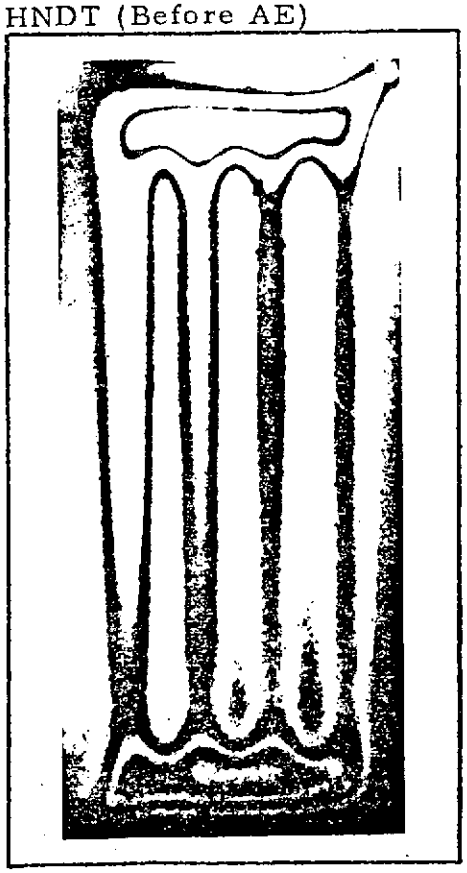
Area of planned full bond which exhibited failure after destructive test. Magnification 50X.

FIGURE C-59

Panel No. B-6

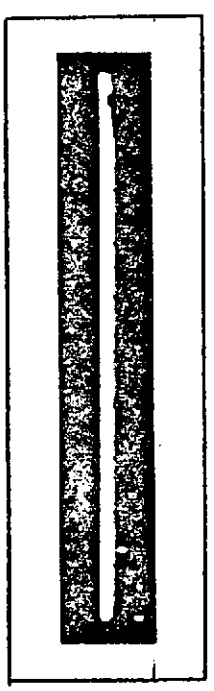


HNDT (Before AE)

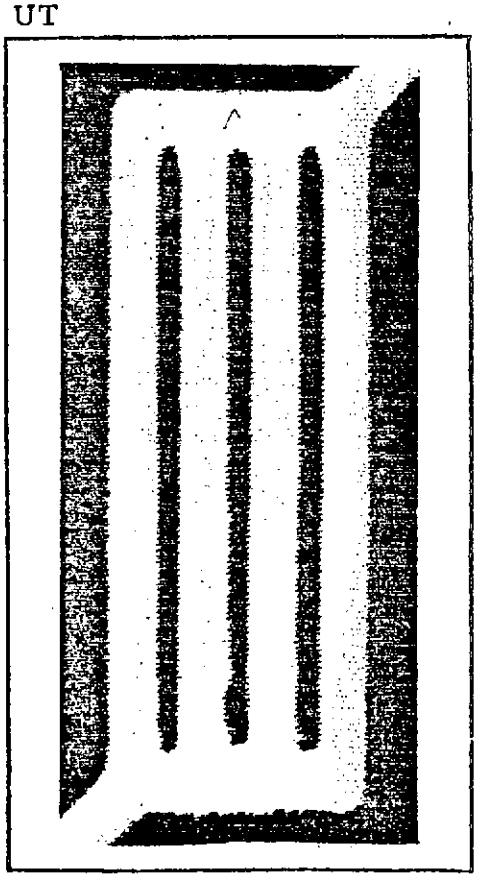


Pres. 20.7 x 10^5 N/M^2
(300 PSI)

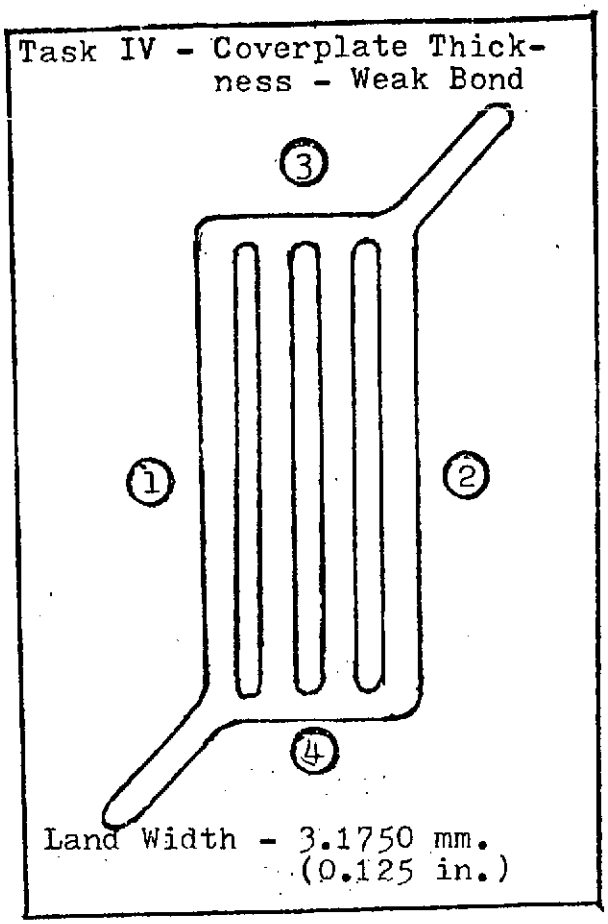
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-19



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.6091	0.2602
②	6.6422	0.2619
③	6.6192	0.2606
④	6.6167	0.2605

COVERPLATE

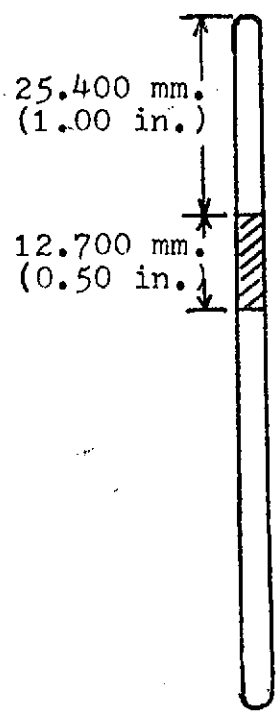
MATERIAL: 347 Stainless Steel

THICKNESS:	MM.	INCHES
①	2.3419	0.0922
②	2.3419	0.0922
③	2.3419	0.0922
④	2.3444	0.0923

PRESSURE REQUIRED TO FAIL BOND:

Not pressurized due to large unplanned nonbond area caused by coverplate warpage.

CENTER LAND DEFECT

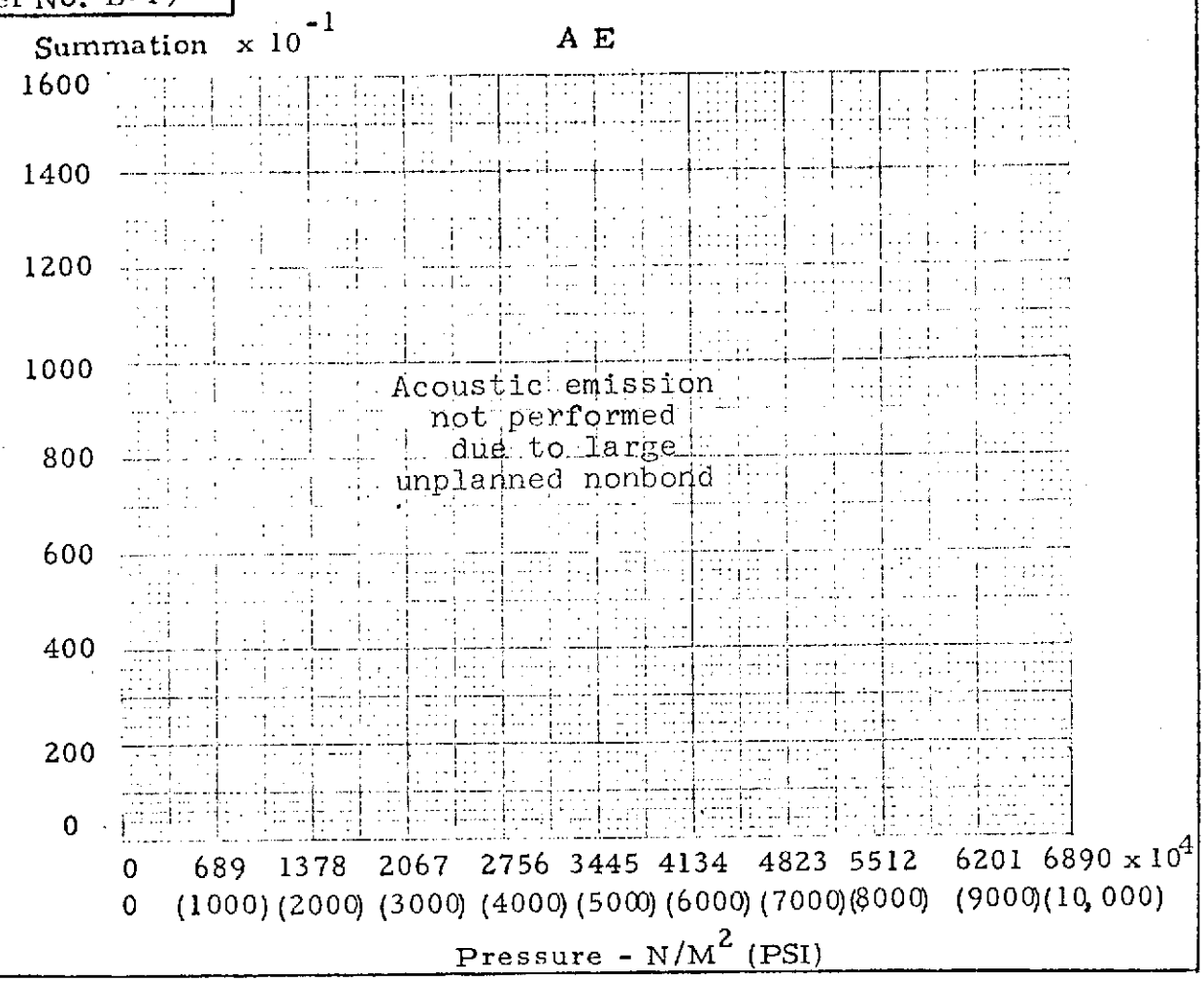


METALLOGRAPHIC ANALYSIS:

Not performed. Panel could not be pressurized due to leakage path.

FIGURE C-60

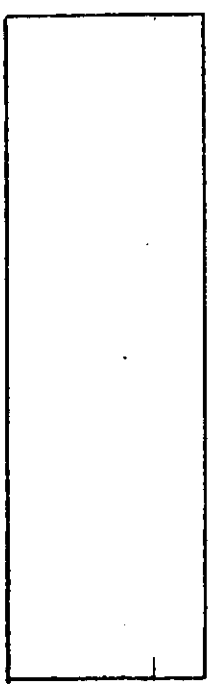
Panel No. B-19



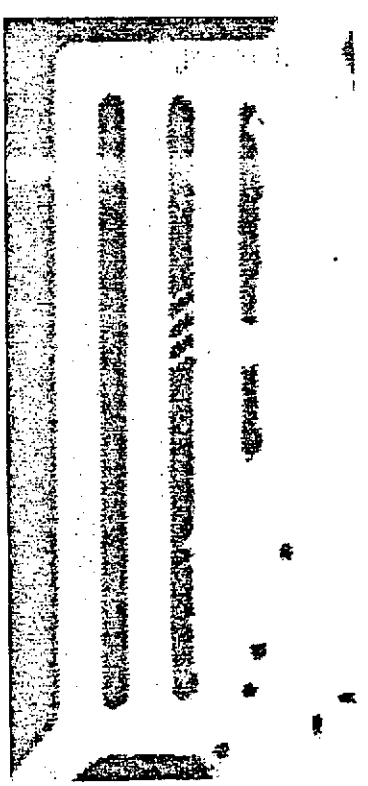
HNDT

No hologram made due to unplanned nonbond as shown in Ultrasonic "C" Scan

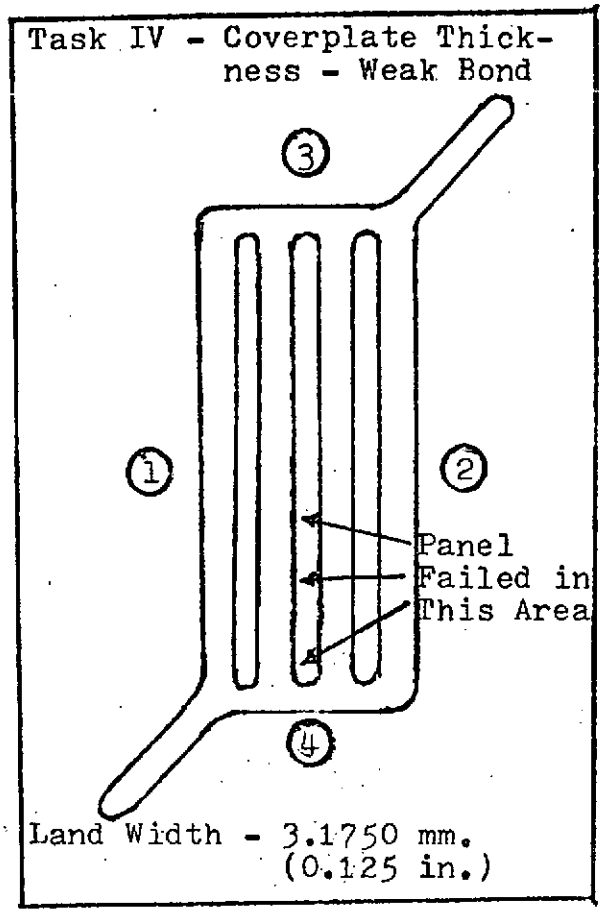
AE
FLAW LOCATOR
CENTER LAND



UT



BRAZED PANEL NO. B-15



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.4364	0.2534
②	6.4389	0.2535
③	6.4237	0.2529
④	6.4287	0.2531

COVERPLATE

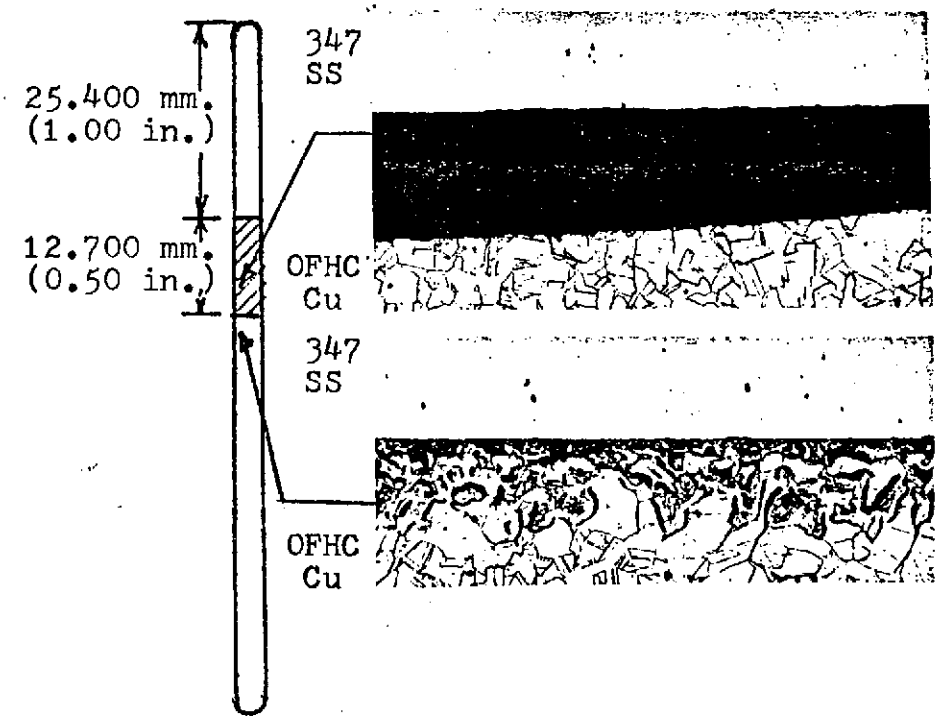
MATERIAL: 347 Stainless Steel

THICKNESS:	MM.	INCHES
①	2.3444	0.0923
②	2.3444	0.0923
③	2.3444	0.0923
④	2.3444	0.0923

PRESSURE REQUIRED TO FAIL BOND:

Braze failed at a pressure of 4.14×10^7 N/m^2 (6,000 psi).

CENTER LAND DEFECT



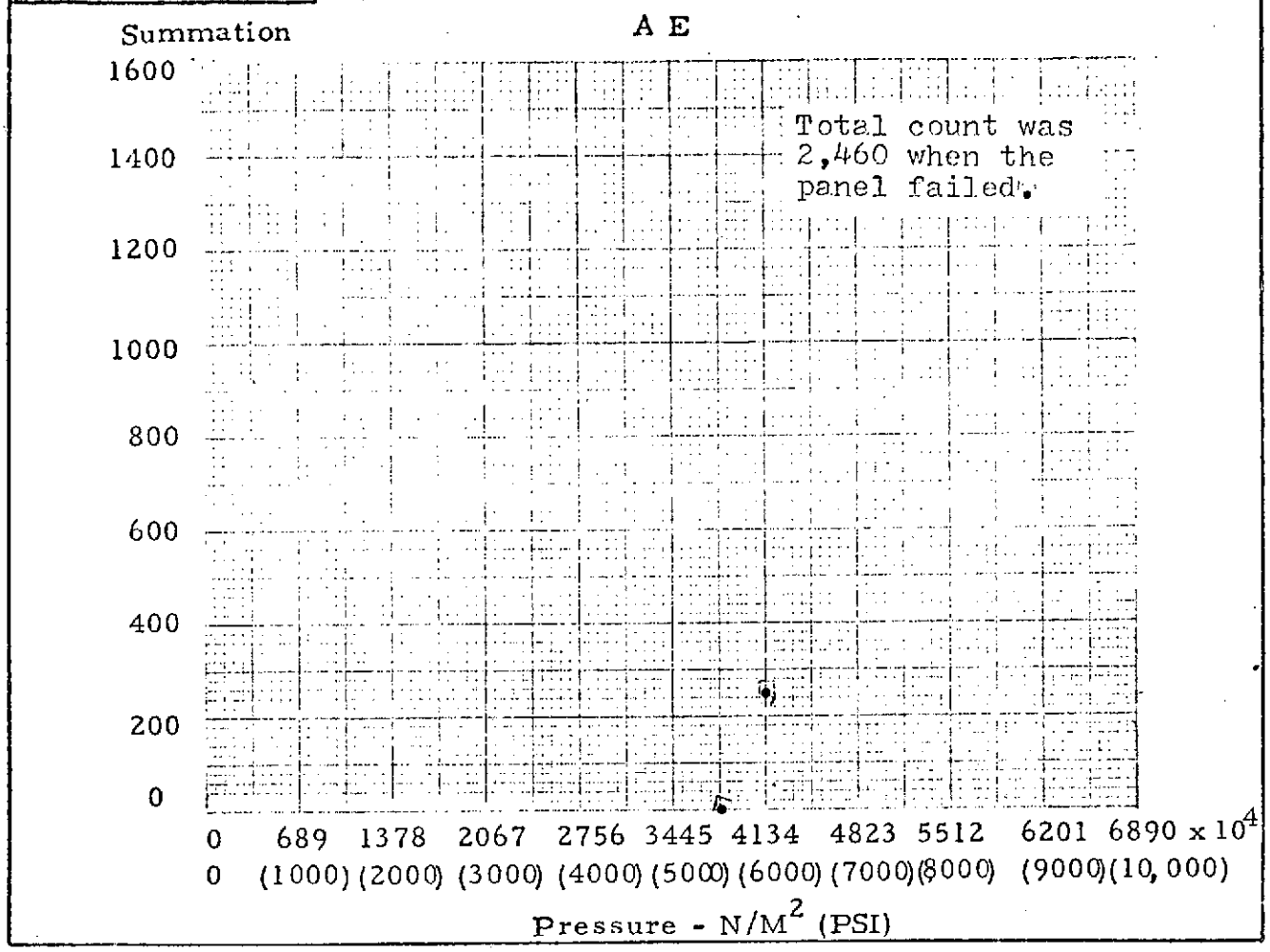
METALLOGRAPHIC ANALYSIS:

Section of planned weakbond which was actually a nonbond due to deficiency of braze alloy in the "weak bond" area. Magnification 50X.

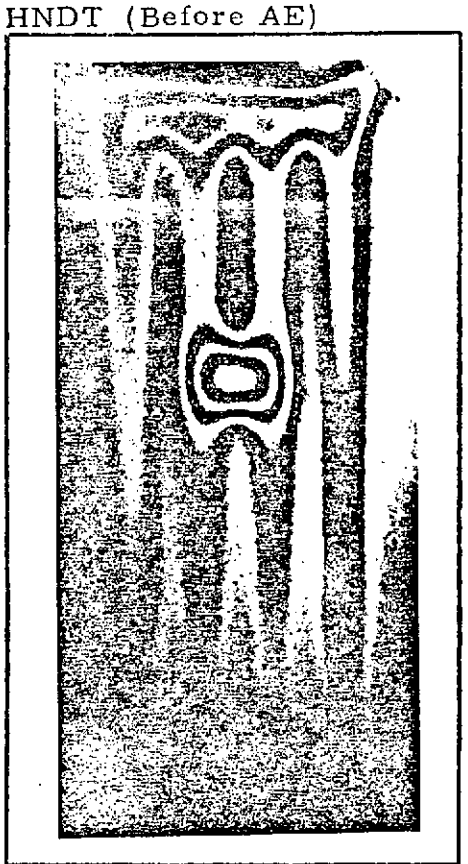
View of planned full bond located adjacent to the planned weak bond. No failure is noted. Magnification 50X.

FIGURE C-61

Panel No. B-15

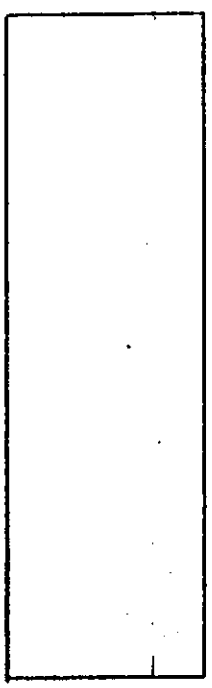


HNDT (Before AE)

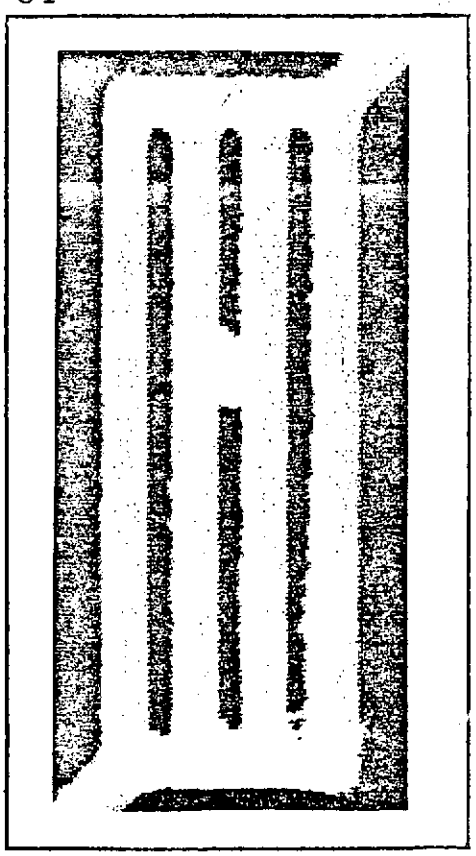


Press. 20.7×10^5 N/M^2
(300 PSI)

AE
FLAW LOCATOR
CENTER LAND

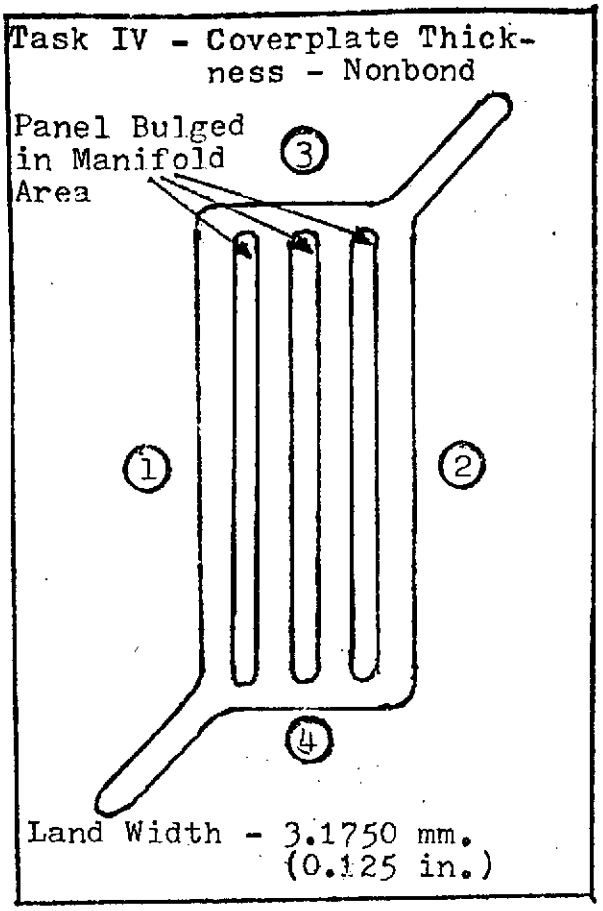


UT



2--3

BRAZED PANEL NO. B-11



BASEPLATE

MATERIAL: OFHC Copper

THICKNESS:	MM.	INCHES
①	6.7716	0.2666
②	6.7335	0.2651
③	6.7437	0.2655
④	6.7666	0.2664

COVERPLATE

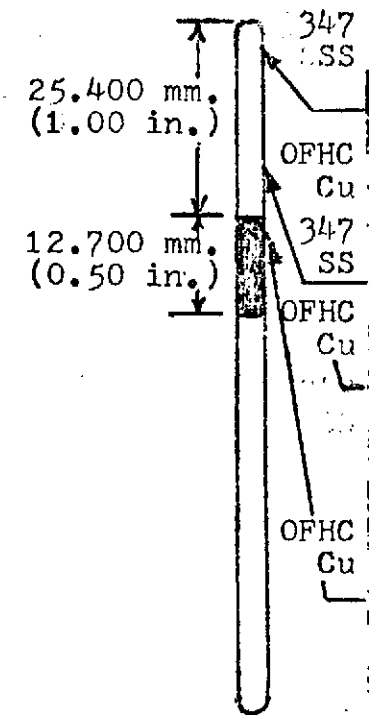
MATERIAL: 347 Stainless Steel

THICKNESS:	MM.	INCHES
①	2.3444	0.0923
②	2.3444	0.0923
③	2.3444	0.0923
④	2.3419	0.0922

PRESSURE REQUIRED TO FAIL BOND:

Bulging occurred at approximately 4.83×10^7 N/m^2 (7,000 psi); the braze failed at 6.90×10^7 N/m^2 (10,000 psi).

CENTER LAND DEFECT



METALLOGRAPHIC ANALYSIS:

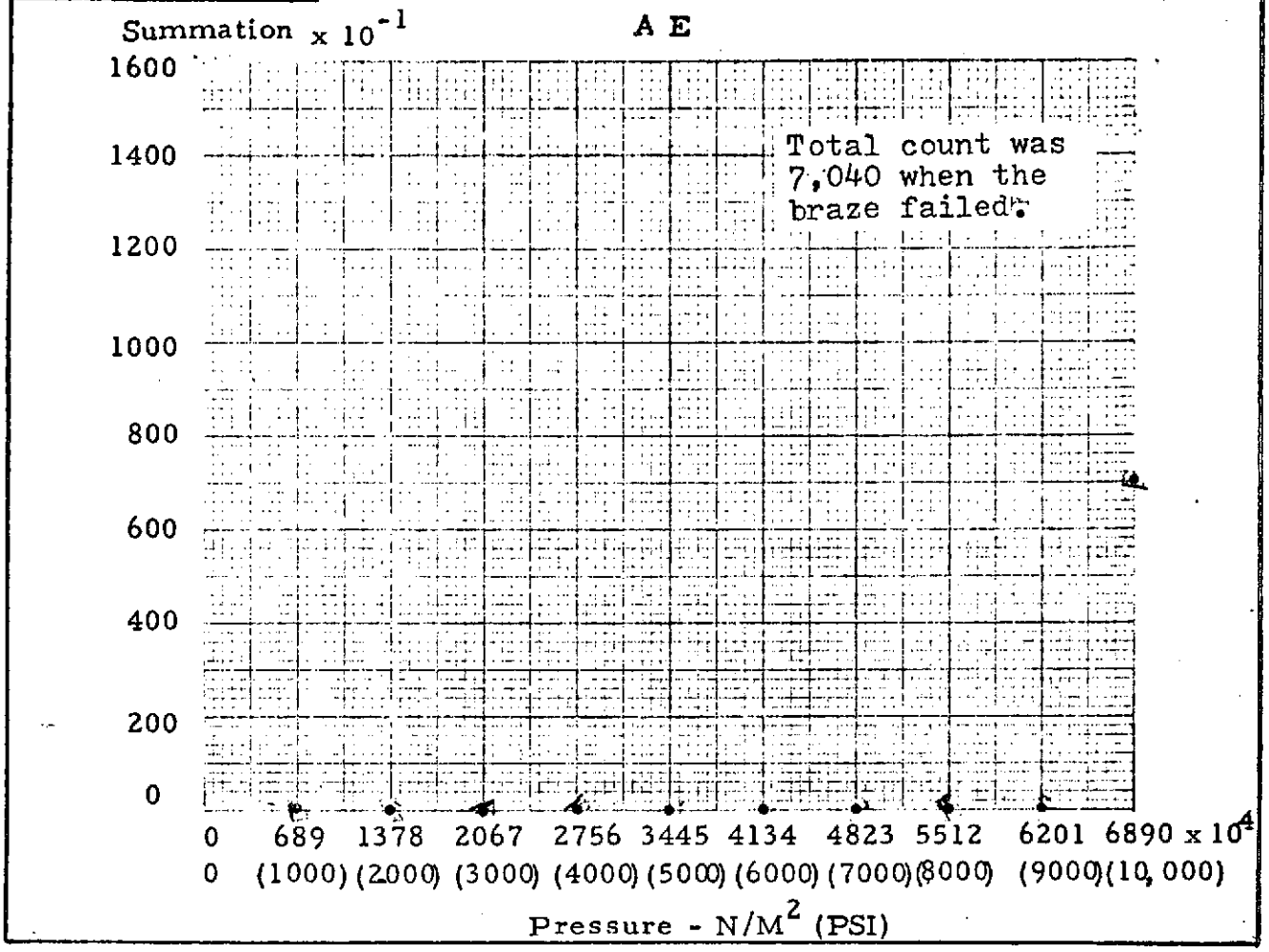
Full bond failure at top manifold end of land. Magnification 50X.

Full bond showing no failure after destructive test. Magnification 50X.

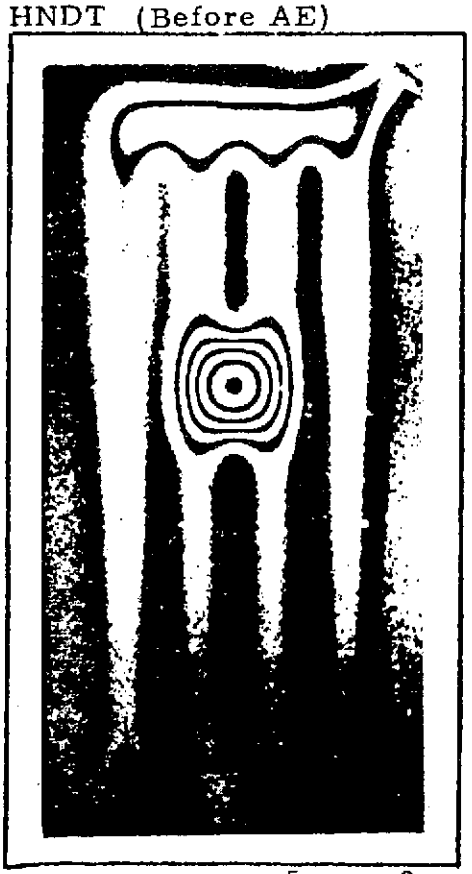
End of planned nonbond defect. No braze wetting is evident in defect. Note yielding of the end bond. Magnification 50X.

FIGURE C-62

Panel No. B-11

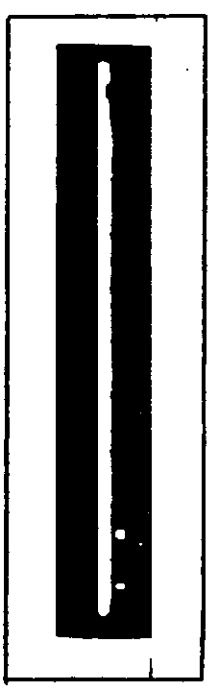


HNDT (Before AE)



Press. 20.7 x 10^5 N/M^2
(300 PSI)

AE
FLAW LOCATOR
CENTER LAND



UT